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THE GENITALIA OF THE AUCHENORHYNCHOUS HOMOPTERA.

By J. C. KERSHAW and F. MUIR.

Most students of insect morphology consider that the male and female genitalia of insects are homologous, but it is also considered that in some groups of insects the female genital opening, or gonopore, is situated between the eighth and ninth abdominal sternites and the male gonopore between the ninth and tenth. So far as the Hemiptera are concerned these two views have never been reconciled, and the fact that the gonapophyses of the two sexes appear to pertain to different segments has been ignored, or used as an argument against the organs being homologous.

Observations made by one of the authors in England upon Cercopidæ and by the other in Honolulu upon Cicadellidæ and Fulgoroidea, agree in showing that the difference is only apparent and is due to development during the last nymphal instar. The gonopore in both sexes is between the eighth and ninth abdominal sternite (or at the base of the ninth sternite) and the three pairs of gonapophyses form the genital appendages.

CERCOPID FEMALE.

Observations were made upon more than one species of this family and our remarks in general apply to all, but the details refer to *Philaenus leucophthalmus* (Linn) which was the chief species used.

In the nymphs the sexes can be recognized in the second instar and it is possible that in carefully prepared specimens they could be recognized in the first instar. In the later nymphal stages they are quite distinct.

Between the eighth and tenth sternites there is an area the anterior portion of which we will call the genital area; anterior to this is the eighth sternite, which is well defined; posterior to it, and between it and the tenth, is an area which may represent the ninth, or it may represent the conjunctiva between the ninth and tenth, and the ninth may be represented in the genital area. From the genital area arises the gonapophyses.

In the female nymphs during the last instar the gonapophyses consist of three pair of subangular, fairly flat processes reaching more than half way back to the tenth sternite. The anterior pair (Fig. 1, g1) arise from the posterior edge of eighth sternite, although at an earlier period their connection with that sternite is not so apparent. The median pair (Fig. 1, g2) are smaller and lie immediately posterior to g1, and as they both point backward and g1 are larger than g2, therefore they lie beneath, or are covered up by g1. The posterior pair (Fig. 1, g3) are larger and hold a more lateral position and are concavo-convex. The genital opening or gonopore is at the base of g2.

In the adult female the eighth abdominal segment is short but well defined. That the segment in question is the eighth can be demonstrated by counting them, especially on the dorsal aspect; the presence of the last, or eighth, spiracle also indicates which segment it is. From the hind margin of the eighth sternite arises two processes (Figs. 2, 3, g1), which form the anterior or ventral process of the ovipositor. These are long, thin and narrow and *their outer basal angles are joined to the outer basal angles of the ninth tergite.* The eighth sternite overlaps their bases, but the membranous connection shows the relationship to the posterior margin of that segment. The ninth segment forms the pygofer (Fig. 2, pg), the tergite being large, but the extent of the sternite obscure and depends upon the composition of the genital area of the nymph. Two sclerites (Fig. 2, bp) which appear to be the valvifers of

Orthoptera, may represent the only chitinized portion of the ninth sternite; they form the supports of the posterior processes.

The median processes (Figs. 2 and 4, g2) lie immediately posterior to the anterior processes and are represented by a single, median process bifurcate on apical third and grooved along the ventral surface. This process is joined to the anterior processes by a tongue and groove joint and together they operate as the ovipositor, the gonopore opening at the base of g2 and the eggs passing along the ventral groove between g1 into the puncture made by the ovipositor. The posterior processes (Figs. 2 and 4, g3) are large and hold a lateral position slightly posterior to g2, and form a sheath for g1 and g2 when at rest. Beyond the pygofer is the anal segment (Fig. 2, 10 and 11) which is composed of the tenth and eleventh segment. Beneath the anus is the anal style (Fig. 2, a. s.), a median organ grooved along its dorsal surface. In no Homopteron, in either the young or adult, are the cerci present so far as we have observed.* Whether an anal style is present in Psocidæ where cerci are absent we are unable to say.

If we dissect an immature imago from the nymphal skin just before it moults we find that the apices of the adult, g1, g2 and g3 rest within the nymphal g1, g2 and g3 so there can be no question as to their homology.

Walker† in his admirable study of the ovipositor of Orthoptera, has shown good reasons for considering g3 as the coxites of the ninth sternite. In the nymphal stages of some Orthoptera g3 carry the styles which are lost before the adult stage is reached. In many Odonata these styles are retained in the adult. In the Cercopidæ there is evidence to indicate that g1 are the coxites of the eighth sternite but none to indicate that g3 are the coxites of the ninth. If they be, then the area between them and the tenth sternite is not the ninth sternite. This leaves g2 as the only true gonapophyses and their origin is open to speculation.

If we consider the genital organs as representing the "legs" of the eighth and ninth segments, then g1 would represent

*Huxley, in The Anatomy of Invertebrated Animals, p. 364, fig. 104, figures an Aphis in which cerci are present. Whether this is supposed to be drawn from an actual specimen or is only a composite figure, we are unable to state.

†Walker, 1919, Ann. Ent. Soc. Am. XIII, p. 267-316.

the coxites* of the eighth sternite, g2 the endopodites and g3 the coxites of the ninth sternite. The style of the abdominal sternites cannot represent the "legs" (endopodites) but the exopodites, unless we consider that the styles on the thoracic coxæ are not their homologies. In *Machilis heteropus* Silv. the "ovipositor" consists of two pair of appendages, one of which represents the endopodite of the ninth sternite and the other the endopodite of the eighth. A careful comparison of the male and female genitalia in a representative series of species of *Machilis* and allied genera would be of great morphological value.

CERCOPID MALE.

In the male nymph of *Philaenus leucophthalmus* (Linn) the gonapophyses arise in exactly the same place as in the female. In the earliest instar of the nymph g2 is a small, single median process, in the following instar it is bilobed at the apex (Figs. 5 and 6). In the last instar the genital processes are smaller than in the female and g1 are not in such close connection with the eighth sternite. A comparison of Figures 1 and 7 indicates the differences between the sexes.

In the adult male the segment behind the eighth forms a ring-like pygofer with the ventral margin produced into a pair of narrow, flat processes (gp) with a longitudinal line of weakness along the middle of the ventral surface (Figs. 8 and 9, g1 or gp). The tenth and eleventh segment form the anal segment, the posterior margin of the former being produced into two large, thick spines curved downward (Fig. 8) and the anterior margin into two small curved processes (Fig. 8). From the middle of the area between the anal segment and the gp of the pygofer arises three processes, a median penis or aedeagus (Fig. 8, p) and a pair of genital styles (Fig. 8, gs). The latter project well into the pygofer as apodemes (Fig. 8, gss) for the attachment of muscles.

If we dissect out an immature imago from the nymphal skin shortly before the final moult we find that the apices of gp lie

*Walker considers g1 and g2 to be similar organs of the eighth and ninth segments. This would make them both endopodites. Certain of the evidence appear to favor his view and we are quite prepared to accept it, but we have used the term coxites as their development in the Homoptera appear to indicate that they are those organs, rather than the endopodites.

within g1, the apex of p within g2 and the apices of gs within g3, but the last is obscure and the more difficult to trace. This shows their true homologies and also shows the homologies of the male and female, which can be represented as follows:

	Nymph	Adult ♂	Adult ♀
Anterior gonapophyses	g1	Genital plates	Outer { Processes of
Median gonapophyses	g2	Aedeagus	Inner { ovipositor
Posterior gonapophyses	g3	Genital styles	Ovipositor Sheaths

In many species of Cercopidæ g1 in the adult male are joined together into a single plate.

COMPOSITION OF THE ÆDEAGUS.

The ædeagus is a complex structure and the homologies of its parts not clear. In the adult *Philaenus leucophthalmus* (Linn) there is a large, chitinous bulb (Fig. 8, pa) which may represent the periandrium, and a straight penis (Fig. 8, p). On the ventral aspect of the apex of the penis is the orifice or gonopore (Fig. 8, gpr). It is possible that during copulation the ejaculatory sac may be protruded or evaginated and the gonopore or functional orifice be situated upon it. Figure 8 shows this sac slightly protruded. At the apex of the penis there are two large, curved hooks, the penis hooks (Fig. 8, ph), and below them four smaller processes in a circle. In the later nymphal stages the area around the base of g2 is invaginated, carrying with it both g2 and the bases of g3, (Fig. 10). The penis hooks (ph) of the adult lie within the bifurcations of g2, (Fig. 11). The bulb or periandrium (pa) evidently arises from the body wall, round the base of g2. The fact that g2 first arises as a single lobe and the bifurcation arises later may indicate that it is only the penis hooks that are homologous to the paired processes of the female and the rest of the ædeagus (the penis and bulb) are formed by outgrowths of the body wall.

Membracidæ

One of the authors* has published notes on the development of the genitalia of a membracid (*Tricentus*). In all its main features it is similar to the Cercopidæ.

Cicadellidæ.

Observations on *Eurymela* and *Deltocephalus mollipes* also show the same development as in the Cercopidæ.

Cicadidæ

No remarks are needed on the female genitalia, as they are the same as in Cercopidæ.

In the male Cicadidæ we have a very distinct type of genitalia. Although we have not followed the details of development so thoroughly as in Cercopidæ, yet enough is known to clearly indicate the line of development and the homologies.

In forms such as *Pompomia maculaticollis* the seventh sternite is large and produced considerably posteriorly where it is slightly emarginate in middle or broadly and slightly bilobed. Whether this extension represents a development of the seventh coxites we cannot say. The eighth sternite forms a large plate which almost conceals the pygofer from below. Posteriorly it narrows to a blunt point at apex, which has a cleft in middle, thus making it bilobed. This represents the eighth sternite and coxites and the eighth spiracles are situated near its basal angles. The pygofer is large, its medioventral surface membranous. From the lateral margins arise a pair of non-articulated processes which represent the much reduced g3. From the middle of the opening of the pygofer arises the ædeagus, which in most Cicadidæ is long, thin and tubular, but in some complex and trilobed. The anal segment is similar in composition to that of the Cercopidæ; in some species it is complex.

If our interpretation of the large plate below, or anterior to, the pygofer, be correct, then it will represent a more generalized type than the Cercopidæ so far as this structure is concerned; but the reduced and non-articulate genital style is a specialization. The plate in question represents the hypandrium.

*Kershaw, 1913, Ann. Soc. en Belgique, 57 (191-201).

The Cicadidæ differ from all other Cicadoidea and Fulgoroidea in that the coxites of the eighth sternites, or g1, are not incorporated into the pygofer, whereas in all the other families they are.

Fulgoroidea.

In the Fulgoroidea we have a third type, which is a development of the Cercopid type. There is a complete pygofer often forming a more or less complete chitinous ring, one pair of articulate genital styles and an ædeagus, which is often very complex. The genus *Tettigometra* is an exception, for along with other Cicadoidean characters it has a pygofer similar to Cercopids, with two pairs of styles. In the genus *Hilda* g1 are more completely amalgamated to the pygofer. On account of the availability of material *Perkinsiella saccharicida* Kirk (Delphacidæ) has been selected as a type, although its small size makes it unsuitable for observing the development.

In the female nymph the ninth tergite forms nearly a complete circle, having a small opening on the ventral aspect (Figs. 12, 9), the anal segment and genital area being sunk into this ring. At the posterior edge of the eighth sternite, between the lateral margins of the ninth tergite, arises the gonapophyses. Only the paired g1 and the single, median g2 are visible, but upon dissecting the g3 are found beneath the larger anterior processes (Fig. 13); g2 is not bilobed at the apex. The homologies of the adult processes can be demonstrated by the apices of the processes of the immature imago lying within the nymphal processes. They are similar to those of the Cercopidæ, but much longer, and as the imago develops within the nymph the base of the ovipositor has to move forward towards the thorax, taking along with it the median portion of the preceding sternites. This causes the abdominal sternites of the adult to be V-shaped and the ovipositor to appear as if arising far anterior to the apex of the abdomen. The pygofer is also carried forward so that it is long and narrow. In many Fulgorids the ovipositor is short and projects beyond the end of the abdomen, or is nearly or quite abortive; in these cases the abdominal sternites are not V-shape.

In the male nymph of *P. saccharicida* the ninth tergite is similar to that of the female, but the gonapophyses are much

smaller and more obscure. In the adult the pygofer forms a ring; from its medio-ventral edge arises two small, laterally flattened spines; a pair of moderately small, flattened genital styles arise near the ventral margin, with a more or less chitinous wall, the diaphragm, dividing them from the ædeagus which is subcylindrical, flattened laterally, with the orifice at the apex on dorsal aspect, with two spines near the orifice. A chitinization of the body wall connects the base of the ædeagus with the base of the anal segment, and there is a chitinous connection between the base of ædeagus and the base of the genital styles.

If we dissect out the immature male from the nymphal skin we find that the body wall at the base of the ædeagus is invaginated, but the genital styles are not carried with it, there being a fold of the body wall between them, (Fig. 19, dia). It is this fold which forms the diaphragm of the adult. At an early stage of development the ædeagus is a simple tubular body with the opening slightly before the apex; the genital styles are proportionally short and flat and the two processes on the ventral margin of pygofer (g1) are relatively large. (Figs. 15, 16 and 17). At the stage shown in Figure 19 they are more than half the length of the genital styles.

In most of the Delphacidæ there is no trace of g1 in the fully developed pygofer; in a few there is a single median process, but the genus *Perkinsiella* has a pair of processes which varies in shape and size in each species. The genus *Pissonotus* shows g1 very well developed (Fig. 20). Among other fulgorids g1 are often well developed (i. e., *Olonia picea*, Eurybrachidæ and *Eurynomeus granulatis*, Achilidæ).

Among the thousand and more genera of the Fulgoroidea the differences of ædeagus are very great, but they can be reduced to three sub-types, which we will refer to as Tettigometroid (A), Delphacoid (B) and Flatoid (C). The Tettigometroid, for other reasons besides the type of male genitalia, we consider as the most primitive type of fulgorid. In the genus Tettigometra the pygofer is of the Cercopid type. In *Hilda breviceps* g1 are incorporated into the pygofer; the periandrium is large and bulb-like and the ædeagus very short, the conjunctiva being distinct; the penis-styles apodemes are well developed. The medio-ventral margin of pygofer is produced.

The more common form of this subtype is found among the Cixiidæ (i. e., *Oliarus*), where the periandrium forms a fairly long tube more or less chitinous and often bearing large spines and other processes, the penis is often complex and produced into processes and more or less membranous so that the conjunctiva is not sharply defined; the penis apodeme passes through the periandrium and joins the base of the penis. The following families have this subtype: Tettigometridæ; Cixiidæ in part; Delphacidæ in part; Tropiduchidæ in part; Derbidæ modified.

In the Flatoid subtype the periandrium is shorter and wider, and generally funnel shape and the penis is invaginated into the periandrium and is also often funnel shape. Both the periandrium and the penis often form a short tube or ring bearing lateral processes. The complexity is very great in some forms (i. e., *Capelopterum maculifrons*, Issidæ). The Meenoplinæ of the Cixiidæ come under this type and thereby add one more character by which they approach the Flatidæ. The following families have this type of ædeagus: Flatidæ, Acanaloniidæ, Ricaniidæ, Issidæ, Dictyophoridæ, Fulgoridæ, Achilidæ, Eurybrachidæ, Lophopidæ and Cixiidæ in part.

The Delphacoide subtype contains Delphacidæ in part and Tropiduchidæ in part. In it the periandrium is greatly reduced or absent and the penis alone forms the ædeagus and is generally tubular. The periandrium generally forms a small ring at the base of the ædeagus and is joined by a chitinous structure to the base of the anal segment.

FURTHER SPECULATIONS.

We consider that the facts briefly stated in this paper are sufficient to demonstrate the homology between the genitalia of the two sexes, and between the Fulgoroidea and the Cicadoidea. There is much work still to be done in all the groups, especially in the Fulgoroidea where the variation in detail, especially in the ædeagus, is very great. Exactly what becomes of the ninth sternite has yet to be shown, also the nature of the area between the ædeagus and the anal segment.

Turning to other orders we find that the Lepidoptera and Trichoptera appear to be built upon the same morphological plan as the Fulgorids. There is a ring-like segment which

appears to be the ninth, a small anal segment, one pair of articulate genital styles and a median ædeagus. They are so similar that it appears only logical to conclude that they have a similar origin and development. At least it urges us to study the pupal stage and the immature imago to see if any evidence of such a development can be found. The Lepidoptera possess no cerci in the males while the Trichoptera possess cerci.

Elsewhere one of the authors has insisted that no evidence has been brought forward to show the homology between the male and female genitalia of Coleoptera, and that in many forms the male gonopore appears to open between the ninth and tenth sternites. If in the Homoptera the coxites can be disassociated from the eighth sternite and become amalgamated with the ninth tergite so as to appear as the ninth sternite, it is highly probable that the same has happened in Coleoptera. But until direct evidence is brought forward showing that such is the case, we must not dogmatically assert that it has. Wherever the hypandrium appears as the ninth sternite we must bear in mind the possibility of it being the coxites of the eighth sternite.

If this homology of the sexes in Coleoptera can be demonstrated, it helps us to understand the wonderful coadaptation between the internal sac and the uterus, for they are then true homologies and the cause which modifies one can modify the other in the same manner. The question is worthy of further study.

EXPLANATION OF PLATE XIII.

Philænus leucophthalmus.

Fig. 1. ♀. Ventral view of VIII-X sternites of nymph, last instar.
Fig. 2. ♀. Lateral view of apical abdominal segments of adult.
Fig. 3. ♀. Anterior processes of ovipositor.
Fig. 4. ♀. Median and posterior processes of ovipositor.
Fig. 5. ♂. Gonapophyses at an early stage.
Fig. 6. ♂. Gonapophyses penultimate nymphal stage.
Fig. 7. ♂. Ventral view of VIII-X sternites of nymph, last instar.
Fig. 8. ♂. Lateral view of apical segments of adult.
Fig. 9. ♂. Ventral view of pygofer.
Fig. 10. ♀. Aedeagus and one genital style of immature adult.
Fig. 11. ♂. Median gonapophyses, last nymphal stage, showing the immature adult stage within it.

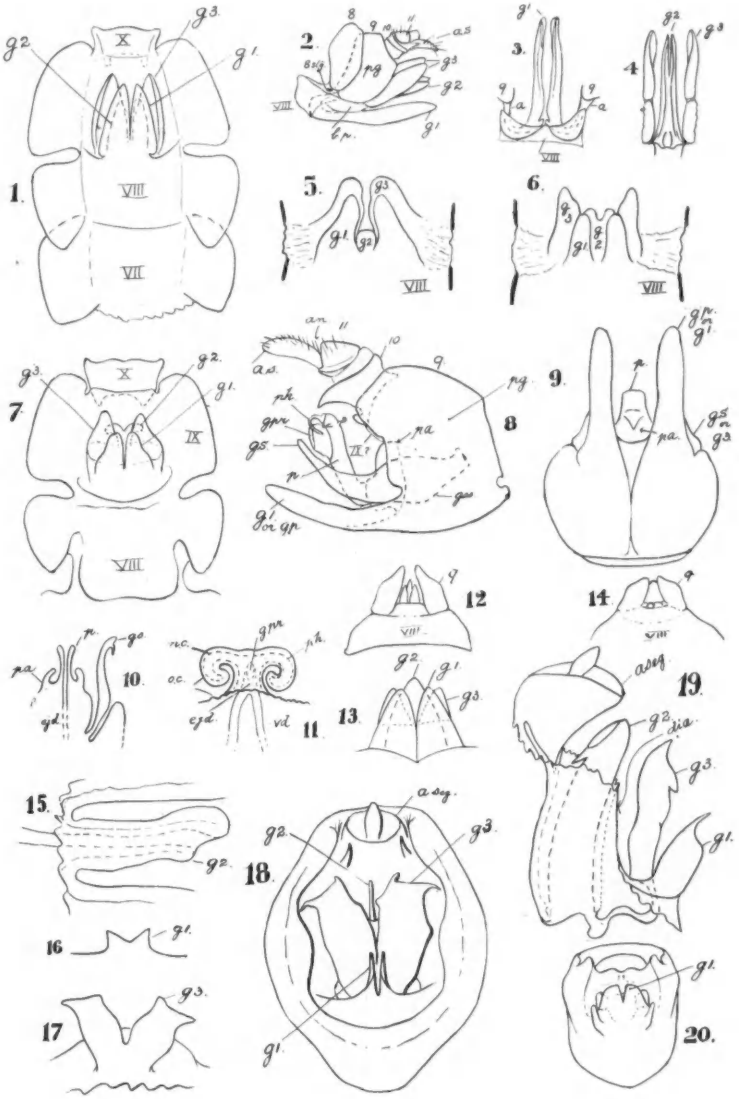
Perkinsiella saccharicida.

Fig. 12. ♀. Ventral view of last abdominal segment of nymph, last instar.
Fig. 13. ♀. Gonapophyses of same, enlarged.
Fig. 14. ♂. Ventral view of last abdominal segments of nymph, last instar.
Fig. 15. ♂. Aedeagus of immature adult.
Fig. 16. ♂. Anterior gonapophyses of immature adult.
Fig. 17. ♂. Posterior gonapophyses of immature adult.
Fig. 18. ♂. Full view of pygofer of immature adult.
Fig. 19. ♂. Lateral view of anal segment, ædeagus, anterior and posterior gonapophyses of immature adult just before final larval moult.

Fig. 20. *Pissonotus frontalis.* Full view of ♂ pygofer.

LETTERING OF FIGURES.

a. seg. = Anal segment.
an = Anus.
as = Anal style.
bp = basal plate.
dia = diaphragm.
ejd = ejaculatory duct.
gpr = gonopore.
gss = apodeme of genital style.
g1 = anterior gonapophyses = *gp* or genital plates.
g2 = median gonapophyses.
g3 = posterior gonapophyses = gs or genital styles.
nc = new cuticle.
oc = old cuticle.
p = penis.
pa—periandrium.
pg = pygofer.
ph = penis hooks.
8 stg = 8th stigma.
8, 9, 10, 11 = tergites.
VIII, IX, X = sternites.



Kershaw and Muir.

THE PHYLOGENY OF THE GALL MITES AND A NEW CLASSIFICATION OF THE SUBORDER PROSTIGMATA OF THE ORDER ACARINA.

By H. E. EWING,
Bureau of Entomology, U. S. Department of Agriculture.

Of all the major groups of the Acarnia it is doubtful if any are more aberrant than the gall mites, and but few show such unity of organization or sameness of habits. Because of this there has been in the past but little evidence upon which to establish any natural affinities between them and any of the other groups, while suggestions as to their origin have been but little more than conjectures.

RECENT VIEWS IN REGARD TO THE AFFINITIES OF THE GALL MITES.

By way of both introduction and review, here are given some of the more recent views in regard to the relationships of the gall mites.

In 1910 Dahl commited himself to the belief that the gall mites were related to the other Acarina through the Tarsonemidæ. He regarded the genus *Tarsonemus* as representing a transitional stage between the Eriophyidæ and the Acarina proper. This belief was held largely because of the nature of the last pair of legs. These legs, normally developed in the free-living Tarsonemidæ, are shortened and almost rudimentary in some of the parasitic species. He found in this group the tendency toward leg reduction which has been so completely effected in the Eriophyidæ.

Banks (1915) champions the Tarsonemid theory. In his well known treatise on the mites he states: "The Eriophyidæ are, perhaps, more closely related to the Tarsonemidæ than to any other group. Many of the Tarsonemidæ feed exposed on the leaves or stems of a plant; some of them cause swellings or deformities of the plant, and some have the body more or less distinctly segmented. Moreover, in several genera of the Tarsonemidæ there is a tendency toward reduction in the number of legs, and in other genera the hind legs are very

slender and of little use in walking." Banks' basis for a belief in Tarsonemid relationship is the existence of similar feeding habits of the two groups and the fact that in the Tarsonemidæ there is "a tendency to the reduction in number of the legs."

Oudemans (1910) states in his review of the families of the Acarina* that the Eriophyidæ are probably most nearly related to the spinning mites or "perhaps even an earlier stage of the Tetranychide." This suggestion that the gall mites are an earlier stage of the Tetranychidæ requires some evidence for its support and an elaboration of explanations based on such evidences. Until such are brought forward the suggestion falls far short of a theory which can be used constructively in the advancement of our knowledge of natural relationships.

A THEORY AS TO THE PHYLOGENY OF THE ERIOPHYIDÆ.

It is my purpose here to state and then substantiate a definite theory as to the origin of the gall mites. The theory is this: The gall mites, a highly aberrant and degeneratively specialized group of phytophagous parasites, have arisen through the process of profound morphological change and adjustment, from a recently discovered group of gall-making spider mites. This group the writer has recognized as a family, the Phytoptipalpidæ, and it is to be regarded as a transitional group between the Eriophyidæ and the Tetranychidæ. I would not derive the gall mites from any living species of the family Phytoptipalpidæ or even from the genus *Phytoptipalpus;* yet it appears from the evidence at hand that the two or more living species of *Phytoptipalpus* are barely out of a line of direct descent between the spider mites and the gall mites.

THE GENUS PHYTOPTIPALPUS—ITS DISCOVERY AND THE INTERPRETATION OF ITS RELATIONSHIPS.

The genus *Phytoptipalpus* was established in 1905 by Tragardh for a very peculiar mite species named by him *paradoxus*, which was found in galls of an African species of *Acacia*. The species was very peculiar in several respects. It evidently was a true gall making species, yet did not belong to the group known as the gall mites. The mites were red,

*Oudemans, A. C. A Short Survey of the More Important Families of Acari. Bul. Ent. Research, Vol. I, pp. 105-119, figs. 1-22.

with a somewhat elongate body, and had even in the adult stage only six legs. The mouth-parts were all but identical with those of the Eriophyidæ, while the tarsal armature was quite similar in some respects to that of certain genera of the Tetranychidæ. The species was oviparous and differed very markedly in its development from that of the spider mites.

Recently the present writer has described* another species of *Phytoptipalpus* taken from the jujube tree (*Zizyphus jujuba*) in India. This species is quite similar to the one described by Tragardh. It makes galls on the bark of the jujube and lives inside of these galls. So similar is this species to Tragardh's *paradoxus* that any phylogenetic significance that attaches to the one should usually apply to the other. The two species are not only congeners, but are very closely related.

The interpretation which the present writer places on the meaning of the peculiar structure of *Phytoptipalpus* is exactly the reverse of that given by Tragardh. Tragardh held that the similarity between the mouth-parts of *Phytoptipalpus* and the Eriophyidæ was due to convergence, hence attached no phylogenetic significance to them and was content to place his new genus in the subfamily Tetranychinæ next to the genus *Tenuipalpus*. He states: "Die so geartete umbildung der Mundteile von *Phytoptipalpus*, welche bei der Gattung *Tenuipalpus* gewissermassen vorbereitet ist, ist ein sehr schones Beisipel von Konvergenz unter dem Einfluss von gleichen ausseren Lebensbedingungen. Die Gattung *Phytoptipalpus* lebt namlich wie die Phytoptiden in Pflanzengallen und ernahrt sich von den Pflanzensaften."

This resemblance which Tragardh explains as being due to convergence, the present writer would ascribe as due chiefly to inheritance. In other words, the Eriophyid type of mouth-parts is similar to the *Phytoptipalpus* type, not because both Eriophyids and the Phytoptipalpi inhabit galls, but chiefly because they have the same ancestry. This thesis I now will attempt to both explain and establish. It involves a consideration of other characters than the mouth-parts and other mites than the two groups mentioned. We will start, however, with the mouth-parts. I will compare first the mouth-parts of the Eriophyidæ with the species of *Phytoptipalpus* with which I have worked. The name of this species is *Phytoptipalpus transitans*.

*Proc. Ent. Soc. Wash., Vol. XXIV, p. 108.

THE MOUTH-PARTS OF THE ERIOPHYIDÆ AND THOSE OF PHYTOPTIPALPUS TRANSITANS EWING.

The close resemblance between the mouth-parts of *Phytoptipalpus* and those of gall mites were clearly recognized when Tragardh established the genus for his species, *paradoxus*. This resemblance was emphasized by giving the genus its name, *Phytoptipalpus*.

In the Eriophyidæ the mouth-parts have been reduced and consolidated. The palpi are no longer free, but have become shortened and fused with their bases to become a trough (Fig. 1) in which lie the needle-like cheliceræ. Evidences of segmentation is retained by the palpi, and three indistinct segments are usually recognized. The cheliceræ (Fig. 1, c) are minute, very slender and needle-like. Those of *Eriophyes pyri* I have detached from the body and find that they arise

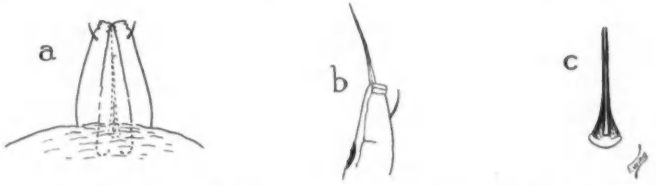


Fig. 1. Mouth-parts of *Eriophyes pyri;* all drawings greatly and equally enlarged. A, dorsal view of capitulum; *b*, side view, showing the palpus, the extended cheliceræ and the ventral mouth-opening; *c*, dorsal view of cheliceræ.

from a common base (Fig. 1, c). The oral opening is conspicuous and is situated on the ventral floor of the fused mouth-parts. This position is typical for other Acarina.

In *Phytoptipalpus* the palpi are reduced and fused so as to form a trough for the cheliceræ. This fusion has been even more complete than in the Eriophyidæ, as only a single segment remains discernible. The cheliceræ are small, very slender and needle-like. They are elbowed near their bases, and the latter are lodged in a well defined mandibular plate. On the ventral side of the fused maxillæ is a conspicuous opening. According to Tragardh it is through this opening in *paradoxus* that the cheliceræ are thrust. In *transitans* the cheliceræ lie in an almost capillary gutter and are thrust from the tip of the capitulum and not at all through this opening. According

to the view of the present writer this opening is no other than the mouth-opening which leads to the pharynx.

So nearly alike are the mouth-parts of *Phytoptipalpus* and those of the Eriophyidæ, that to explain their complete homology it is only necessary to point out their few differences. The maxillæ and the maxillary palpi are practically the same in both cases except in *Phytoptipalpus* only a single fused palpal segment is distinguishable, while in the Eriophyidæ three are usually recognizable. The stylets of the cheliceræ of the two groups are the same, except that in *Phytoptipalpus* they are elbowed near the base. In *Phytoptipalpus* and all of the spider mites the bases of the cheliceræ are lodged in a flat chitinous structure which may be in certain species

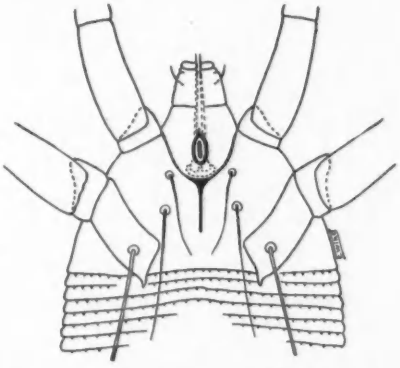


Fig. 2. Ventral view of anterior part of body of *Eriophyes pyri;* greatly enlarged.

protrusible. This structure has long been known as the mandibular plate. In working on the homologies of the mouth-parts of the Eriophyidæ the writer has found that in *E. pyri* that the cheliceræ both arise from a common base, and that this base could logically be regarded as the same structure which in the Tetranychidæ and in *Phytoptipalpus* is called the mandibular plate. It is a greatly reduced structure in the Eriophyidæ and in fact is vestigial.

The pharynx and oral opening in the two groups of mites are, as I have found, identical, although Tragardh regarded the ventral opening in *paradoxus* as being a provision for the thrusting out of the cheliceræ.

THE TARSAL ARMATURE IN THE ERIOPHYIDÆ AND IN PHYTOPTIPALPUS.

The Tarsonemid theory of the origin of the Eriophyidæ fails utterly to explain the presence of the peculiar tarsal armature of the gall mites. In the Eriophyidæ each tarsus is armed at its tip with a simple claw and below it with the pectinate structure known as the "feather hair" (Fig. 3, *c*). The so-called "feather hair" is composed of an almost straight central part from which branch off below four or five pairs of barbs.

Of all the groups of the Acarina no other group gives as close an approximation to the Eriophyid type of tarsal armature as the red spiders, or spider mites. Of the various genera of

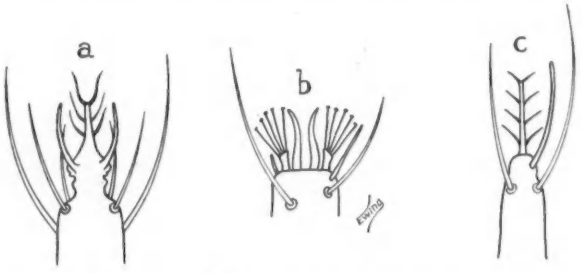


Fig. 3. Tarsal armatures of *Syncaligus, a;* of *Phytoptipalpus, b;* and of *Eriophyes, c.*

the spider mites the genus *Syncaligus*, a genus showing many relationships with *Phytoptipalpus*, has a tarsal armature most nearly like that of the Eriophyidæ. In this genus there is a ventral structure, the empodium (Fig. 3, *a*), which differs from the "feather hair" of the Eriophyidæ only in being stouter and having one or two less barbs, or branches. In addition to the empodium in *Syncaligus*, two tarsal claws are present. It is from the *Syncaligus* type of tarsus that the tarsal armature of both *Phytoptipalpus* and the Eriophyidæ have probably been developed; in *Phytoptipalpus* by the splitting of the empodium into two and an increasing of the number of its branches, and in the Eriophyidæ by the atrophy of one of the tarsal claws. That one of the tarsal claws is easily lost is shown repeatedly in the Acarina. Even in the Tetranychidæ it is now

taking place in the genus *Paratetranychus*, has taken place in genera *Tetranychus* and *Oligonychus;* while in another genus in the same family, the genus *Anychus*, both claws are gone.

Thus it is seen that not only is the Eriophyid tarsus structurally more nearly related to a type found in the Tetranychidæ, but it can be homologized with the latter type, and the evolutionary changes necessary to give the exact Eriophyid tarsus are actually observed now in progress in the group from which we would derive the Eriophyids.

THE FORM OF THE BODY IN THE ERIOPHYIDÆ AND THE TETRANYCHIDÆ.

Next in morphological importance to the structure of the mouth-parts and of the tarsal armature and number of legs in the Eriophyidæ, is probably the form of the body. It is in nearly all species vermiform, in fact one of the common names of the suborder of gall mites is Vermiformia. In addition, the long-drawn-out body is ringed with many circular folds of the integument.

This ringed, vermiform condition is only matched in the hair follicle mites of all the other major mite groups, and the hair follicle mites are so different from the gall mites in practically all other respects that a suggestion of their affinity with the Eriophyidæ has never even been made.

Undoubtedly the vermiform body of a hair follicle mite is an adaptation—an absolutely necessary adaptation—to its life in the hair follicles, and with almost complete assurance we can accept it that their origin and descent is from some ectoparasitic zoophagous group, probably from the parasitic Cheyletidæ as held by Hirst.

Searching elsewhere in the different groups of the Acarina, instances of a vermiform tendency are found in several of them and as has been noted, exists in the Tarsonemidæ, more particularly, however, in the female, for the males of the Tarsonemids are as a rule short-bodied. In the Tetranychidæ we find not only examples of this tendency to develop the vermiform type of body, but it is correlated with the development of the gall-producing habit.

In such free-living and active genera as *Tetranychus* and *Paratetranychus* the body is stout, but in other genera where the attacks of the mites are so restricted that they live almost

as fixed parasites, the body becomes more flattened and usually elongate. Then in such species as *Stigmaeus floridanus* Banks, which lives in colonies at the bases of imbricated leaves of the pineapple, the body becomes markedly lengthened. Finally, in the genus *Phytoptipalpus* we find not only a lengthened body, but in the male particularly the body ringed in almost the same way as in the Eriophyidæ. (Fig. 4).

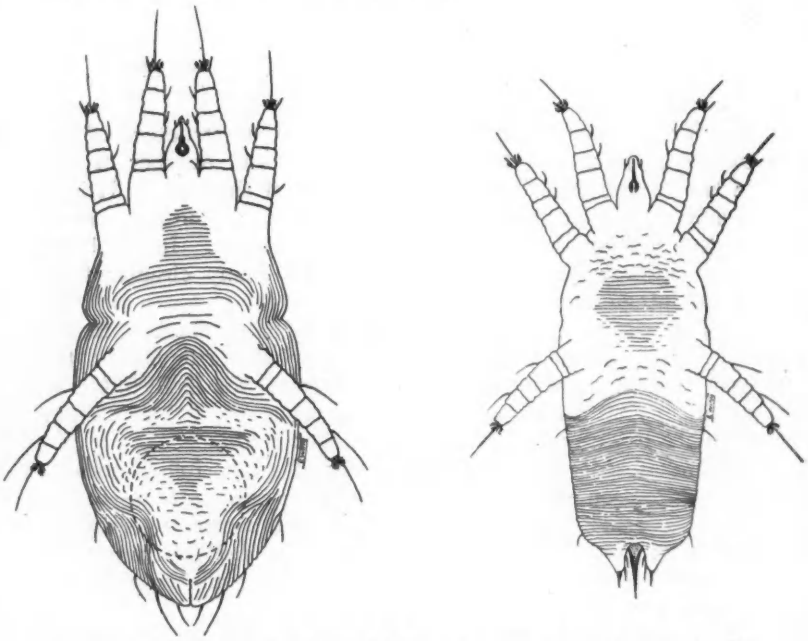


Fig. 4. *Phytoptipalpus transitans* Ewing. Ventral views of male (smaller individual) and female (larger individual) equally enlarged.

SUMMARY OF RELATIONSHIPS.

Thus it is found that in what probably constitutes the three most important groups of morphological structures in the gall mites, that these structures can be homologized with those of the same groups in the Phytoptipalpidæ. Further, it is observed that all modifications necessary to give the types of these three important group of characters in the Eriophyidæ can be explained, and what is more important, the processes of change

can actually be traced out not only in other groups of mites, but in the Tetranychidæ and the Phytoptipalpidæ the two families held to be the most nearly related to the Eriophyidæ. Lastly the morphological changes thus traced out are correlated with changes in habits which give finally a high degree of approximation between the hypothetical ancestral group and the group whose origin is to be explained.

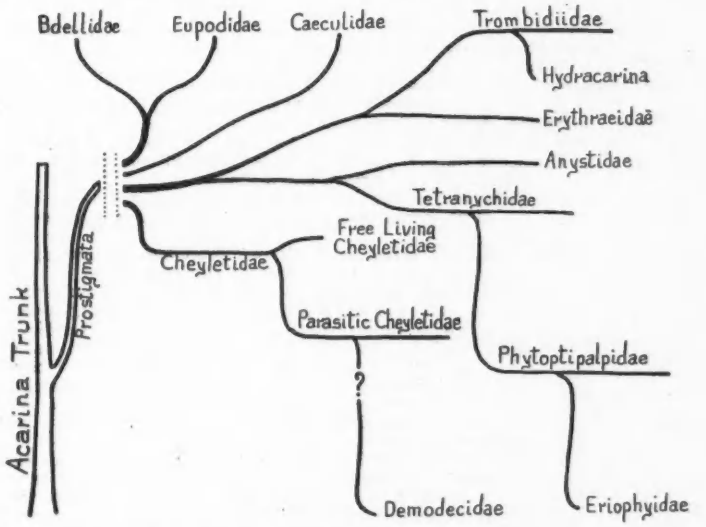


Fig. 5. A "tree" diagram illustrating the origin and relationships of the families of Prostigmata.

The relationship and origin of the Eriophyidæ is indicated in the following diagram (Fig. 5). For sake of completeness the relationships of other families of the order Prostigmata are also shown according to the writer's interpretation.

The same relationships can be shown in the form of a key to the families of Prostigmata; not so clearly, yet some practical advantage may be obtained in the key by enabling one to place properly a given species to family. A key to the families of the suborder Prostigmata is here given in the form of a new classification. In this classification the mouth-parts are made, to a large extent, the basis for family differentiation.

A NEW CLASSIFICATION OF THE SUBORDER PROSTIGMATA.

A. Cheliceræ chelate; adapted for biting; palpi without thumb, Section ADACTYLOGNATHA
  B. Mouth-parts not formed into a beak; palpi neither geniculate or raptorial.....*Eupodidæ*
  BB. Mouth-parts formed into a conspicuous beak; palpi either geniculate or raptorial.....*Bdellidæ*
AA. Cheliceræ either falcate or needle-pointed, adapted for piercing.
  B. Legs usually adapted for swimming. Aquatic mites, Section HYDRACARINA
    C. Mouth-parts not situated on a beak. Fresh water mites, *Hydrachnidæ*
    CC. Mouth-parts situated on a more or less distinct beak. Marine mites.....*Halacaridæ*
  BB. Legs not adapted for swimming. Mites not aquatic.
    C. Legs composed of more than three segments; palpi provided with a thumb, except in degenerate forms, in which case they are fused with the maxillæ.....Section DACTYLOGNATHA
      D. Cheliceræ falcate; palpi free, five-segmented and with the last segment always formed into a thumb.
        E. First and second legs provided with processes bearing large spines; integument with large chitinous shields, *Caeculidæ*
        EE. First and second legs without processes bearing spines; integument without any large chitinous shield.
          F. Cephalothorax with a rod-like structure at the bottom of a median dorsal groove; legs stouter and usually with swollen tarsi.....*Trombidiidæ*
          FF. Cephalothorax without rod-like structure and median dorsal groove; legs more slender and tarsi never swollen.....*Anystidæ*
      DD. Cheliceræ not falcate but either styletiform or needle-like; palpi frequently reduced in size and number of segments, and variously modified.
        E. Cephalothorax with a rod-like structure at the bottom of a median dorsal groove; tarsi not attenuated, but on the contrary frequently swollen; body well clothed with short setæ.....*Erythraeidæ*
        EE. Cephalothorax without rod-like structure and median dorsal groove; tarsi tapering from base to apex; body sparesly clothed with setæ of varying lengths.
          F. Each tarsus provided with either a pectinate distal appendage or tenent hairs, or both of these; palpi moderate or small; phytophagous in habits.
            G. Adults with four pairs of legs; palpi free; never producing galls.....*Tetranychidæ*
            GG. Adults with less than four pair of legs; palpi greatly reduced and united ventrally to form a trough for the needle-like cheliceræ; usually producing and inhabiting galls.
              H. Body not vermiform; adults with six legs; each tarsus provided with two claws and two "feather hairs;" gall makers. *Phytoptipalpidæ*
              HH. Body vermiform; adults with only four legs; each tarsus provided distally only with a single claw and "feather hair".. *Eriophyidæ*
          FF. Tarsus usually without pectinate appendages and always without tenent hairs; palpi usually large; predaceous or parasitic in habits.....*Cheyletidæ*
    CC. Legs stumpy and composed of only three segments; body vermiform. Parasitic mites.....Section BRACHYPODA
      One family.....*Demodec'dæ*

UNDESCRIBED SPECIES OF CRANE-FLIES FROM NEW ZEALAND.

(Tipulidæ, Diptera).

By Charles P. Alexander.

The new species of New Zealand Tipulidæ described in this paper were included in extensive collections sent to the writer by Dr. Campbell, collected by Messrs. Gourlay, Harris, Howes and himself; collections from Dr. Tillyard and Mr. Philpott in the Cawthron Institute; and a small but interesting lot from the alpine zone of Mt. Ruapehu, sent by Mr. Watt. The writer is very greatly indebted to all the above mentioned gentlemen for this material. The holotypes are preserved in the writer's collection except where stated to the contrary.

Mr. F. W. Edwards, of the British Museum of Natural History, has recently completed a monographic review of the New Zealand Tipuloidea. The writer would express his most sincere gratitude to Mr. Edwards for the privilege of studying this manuscript in advance of publication. The appearance in press of this great work will do much to stimulate the study of the very interesting crane-fly fauna of New Zealand. In addition, the writer has availed himself of the opportunity to submit certain doubtful species of the very large genus *Gynoplistia* to Mr. Edwards for his expert opinion and comparison with the unrivalled series of types of New Zealand Tipuloidea in the collection of the British Museum.

Dicranomyia subviridis, sp. n.

General coloration light yellow; antennæ dark brown; wings nearly hyaline, the costa tinged with green; *Sc* ending far before the origin of *Rs*; *Rs* short, about equal to the deflection of R_{4+5}.

Male.—Length about 5.5 mm.; wing 6.5 mm. *Female.*—Length 6.2 mm.; wing 7.2 mm.

Rostrum pale obscure yellow; palpi light brown. Antennæ dark brown, the scapal segments very little paler; flagellar segments submoniliform in the female, slightly more elongate in the male. Head yellow, paler posteriorly, passing into gray on the genæ.

Mesonotum clear yellow, unmarked, scutellum and median area of scutum almost white. Pleura concolorous. Halteres pale, the knobs a little darker. Legs with the coxæ and trochanters pale, tinged with green; remainder of legs pale, the terminal tarsal segments dark brown. Wings nearly hyaline, iridescent, the veins strongly tinged with green, especially the outer end of costa. Venation: *Sc* short, Sc_1 ending far before the origin of *Rs*, the distance being nearly, if not quite, twice *Rs*; Sc_2 apparently lacking; *Rs* short, subobsolete, entirely without macrotrichiæ, subequal to, or shorter than, the deflection of R_{4+5}; cell *1st* M_2 closed; basal deflection of Cu_1 before the fork of *M*.

Abdomen pale brownish yellow, unmarked; in the female, the basal segments are infuscated but this is apparently due to dried egg-masses within the body; ovipositor reddish, the bases of the valves tinged with green.

Hab. New Zealand (South Island). *Holotype*, ♂, Nelson, November 8, 1920 (*A. Philpott*). *Allotopotype*, ♀, October 23, 1920. *Paratopotype*, ♀, October 23, 1920.

Type in the collection of the Cawthron Institute.

In its general appearance, *D. subviridis* is strikingly like *D. conveniens* (Walker), a very different fly. It belongs to the *monilicornis* group, distinguished by the short subcosta, very short sector and closed cell *1st* M_2.

Dicranomyia sperata, sp. n.

General coloration obscure brownish yellow; head dark brownish black; wings whitish subhyaline with conspicuous pale brown washes, the most conspicuous at the wing-tip; *Sc* long; *r* long and strongly arcuated; cell *1st* M_2 long and narrow, the basal deflection of Cu_1 at the middle of its length.

Female.—Length 9 mm.; wing 10.5 mm. Described from an alcoholic specimen.

Rostrum and palpi dark brown. Antennæ dark brown, the second scapal segment a little paler. Head dark brownish black.

Mesonotum light brownish yellow, the præscutum with three slightly darker brown stripes; scutal lobes also darker brown; scutellum more yellowish. Pleura obscure yellow, the mesosternum faintly darkened. Halteres obscure yellow, the knobs dark brown. Legs light brown, the femoral bases a little lighter, the terminal tarsal segments dark brown. Wings whitish subhyaline with conspicuous pale brown washes; cells *C* and *Sc* light brown; a brown wash along vein *Cu* and another near midlength of *1st A*; anal angle of wing faintly darkened; cord and outer end of cell *1st* M_2 narrowly seamed with brown; stigma elongate, brown; the most conspicuous brown wash occupies the wing-tip beyond cell *1st* M_2 including about the outer half of cells *2nd* R_1 and R_3; all except the base of R_5; all of *2nd* M_1; the cephalic half of M_3;

veins dark brown. Venation: *Sc* long, Sc_1 ending just beyond midlength of *Rs*, Sc_2 near mid-distance between the origin of *Rs* and the tip of Sc_1; *Rs* long, provided with seven macrotrichiæ; *r* very long and strongly arcuated, longer than the basal deflection of Cu_1, located at the tip of R_1; deflection of R_{1+5} angulated and spurred; cell *1st* M_2 long and narrow; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdominal tergites yellowish brown the sternites a little darker with the incisures narrowly and indistinctly pale. Ovipositor with elongate valves.

Hab. New Zealand (South Island). *Holotype*, ♀ Mt. Grey, Canterbury, November, 1916 (*J. W. Campbell*). *Paratypes* ♀♀, Ben Lomond Otago, December 30, 1921, January 2, 1922, (Geo. Howes).

Amphineurus senex, sp. n.

General coloration brown; wings and legs unvariegated; *Rs* square at origin; R_{2+5} short but evident; cell 1st M_2 closed. *Male.*—Length 4.3 mm.; wing 5.5 mm.

Rostrum and palpi dark brown. Antennæ with the scapal segments dark brown; flagellar segments obscure yellow, with conspicuous erect, black verticils. Head greyish ochraceous, the vertex with very conspicuous, light yellow, scale-like hairs.

Mesonotal præscutum greyish ochraceous with two narrow dark brown intermediate stripes, very narrowly and indistinctly separated by a capillary pale line; lateral stripes not indicated; pseudo-sutural foveæ very conspicuous, elongate, lying transversely, dark brown; tuberculate pits lying a little cephalad of the level of the foveæ, pale, one on either side of the capillary pale line; remainder of mesonotum light brown. Pleura light brownish grey variegated with darker brown; a group of conspicuous yellow hairs beneath the wing-root. Halteres yellow, the stem, except the base, densely clothed with appressed, dusky scale-like hairs; apex of knobs yellowish. Legs with the coxæ and trochanters obscure yellow, the former clothed with yellow scale-like hairs; remainder of the legs dark brown. Wings greyish subhyaline, the veins and membrane densely clothed with brown macrotrichiæ to almost completely conceal the coloration; veins pale brown. Venation: *Rs* almost square at origin, feebly spurred; R_{2+3} short, about equal to the deflection of R_{1+5}; *r* on R_2 about twice its length beyond the fork; cell *1st* M_2 closed, long and narrow, gradually widened distally; *m* nearly three times as long as the outer deflection of M_3; basal deflection of Cu_1 just before the fork of *M*.

Abdomen dark brown, clothed with yellow hairs. Male hypopygium with the apices of the pleurites long-drawn-out, contiguous at their tips; the forceps at base of pleurites slender, acicular, curved, clothed on the inner face with pale erect hairs; second pair of forceps larger, black, compressed, the tips slender, curved and directed laterad.

Hab. New Zealand (South Island). *Holotype*, ♂, Old Man Range, Otago, January, 1920 (*Geo. Howes*). *Amphineurus senex* is allied to *A. perdecorus* Edwards.

Gynoplistia lyrifera, sp. n.

Head grey; mesonotal praescutum and scutum shiny brownish black, the lateral margins of the præscutum and the postnotum with a microscopic grey pubescence; scutellum obscure yellow; wings subhyaline with a heavy brown pattern; abdominal tergites bicolorous; gonapophyses of male hypopygium lyriform. *Male.*—Length 11 mm.; wing 10.6 mm.

Rostrum dark, dusted with gray; palpi dark brown. Antennæ with the first scapal segment dark brown; remainder of antennæ broken. Head light gray.

Pronotum light grey. Mesonotal præscutum shiny brownish black, more reddish near the suture, the humeral region and lateral margins conspicuously light grey; it is possible but scarcely probable that the specimen may be rubbed and the disk of the præscutum normally dull; scutal lobes shiny brownish black, the caudal lateral margin yellow, the caudal median area gray; scutellum conspicuously obscure yellow with a median spot at the base, the caudal margin with conspicuous setæ; postnotum shiny reddish brown with a sparse microscopic grey pubescence. Pleura brown with a heavy microscopic grey pubescence, the dorso-pleural membrane and the lateral sclerite of the postnotum brownish black, the latter heavily grey pubescent; mesosternum dark brown laterally, narrowly pale medially. Halteres with the stem obscure brownish yellow, the knobs broken. Legs with the coxæ pale brownish yellow, covered with a heavy whitish microscopic pubescence; trochanters obscure yellow; remainder of the legs broken. Wings subhyaline, heavily spotted and clouded with brown; cell *Sc* pale brown on the basal half; a large subquadrate dark brown spot at origin of *Rs*, not attaining *M;* stigmal area large, continued caudad along the cord to *r-m*, this area including the apices of cells *1st* R_1 and *R* and the bases of cells R_3 and R_5; remainder of cord and outer end of cell *1st* M_2 narrowly seamed with paler brown; wing-apex broadly pale brown, including the tip of cell R_2, a little less than the outer half of cells R_3 and R_5 and all of M_1 except the base which is clear; a pale brown cloud in the end of cell Cu_1; an extensive pale brown cloud occupies the basal half of cell *Cu* and the outer end of cell *1st A* above the end of vein *2nd A;* no darkening at base of cells *R* or *M;* veins dark brown. Venation; Sc_1 ending about opposite midlength of R_{2+3}; R_{2+3} and basal deflection of R_{4+5} subequal; tip of R_1 and *r* subevanescent, without macrotrichiæ; petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 at from two-thirds to three-fourths the length of the cell.

Abdominal tergites indistinctly bicolorous, the apical half of the segments shiny black, the basal half reddish brown with a sparse light

grey microscopic pubescence; a darker subterminal ring; hypopygium orange-yellow. Hypopygium with the pleurites short and stout, the caudal-proximal angle produced into a short stout lobe that bears a dense tuft of short bristles; a yellowish flattened lobe at base of pleurite on proximal face; the two usual pleural appendages are broadly united basally, the outer lobe broad-based, tapering distally, the tip suddenly narrowed into a curved point, not blackened or provided with spines; inner lobe broad-based, suddenly narrowed to the slender neck, the head slightly enlarged but unarmed. The two gonapophyses are very conspicuous, taken together appearing lyriform, each about as long as the pleurite, gently curved outwardly, deeply bifid at tip, the arms not divergent, lateral arm twice as long as the straight inner arm and curved strongly laterad. Penis-guard broad-based, tapering suddenly to the apex, much shorter than the gonapophyses.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*).

Gynoplistia trispinosa, sp. n.

General coloration reddish brown, the mesonotal præscutum more blackened, especially laterally; pleura whitish, the dorso-pleural region narrowly blackened; femora without pale rings; wings subhyaline with a very restricted pattern; abdomen reddish brown; male hypopygium with the outer pleural appendage a paddle-like, blackened blade; gonapophyses on either side with three spines. *Male.*—Length 14 mm.; wing 13 mm.

Rostrum reddish; basal segment of palpus reddish, the terminal segments dark brown. Antennæ with the scapal segments yellow, the flagellum dark brown with only the base of the first segment a little paler; antennæ 21-segmented, the formula being 2+2+14+3; longest flabellation about six times as long as the segment. Head black, the occiput more reddish; a very faint, appressed, gray pubescence.

Pronotum brown, the scutellum shiny yellow, only slightly infuscated medially. Mesonotal præscutum shiny brownish black, the stripes entirely confluent, the median stripe tinged with reddish; humeral region reddish brown; remainder of mesonotum shiny reddish brown. Pleura reddish brown with a heavy, microscopic, white pubescence, the dorso-pleural region narrowly blackened; mesosternum more reddish. Halteres brownish yellow, the knobs darker. Legs with the coxæ heavily white pubescent as on the pleura; trochanters reddish; femora reddish brown, the tips slightly darker; tibiæ brown, the tips narrowly darker; tarsi dark brown. Wings subhyaline; cell *Sc* and stigma brown; a small, circular, brown spot at origin of *Rs;* very narrow brown seams along the cord and outer end of cell *1st* M_2; wing-tip in cells R_3, R_5 and M_1 very faintly clouded with brown; a faint brown seam along vein *Cu* to the wing-margin; a faint wash near midlength of vein *1st A;* veins

dark brown. Venation: *r* at tip of R_1 and at two-thirds R_2; cell M_1 only a little longer than its petiole; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdomen uniformly reddish brown; a very faint and indistinct, capillary, brown, median line, broadly interrupted at the posterior margin of the segments. Male hypopygium reddish brown; outer pleural appendage broad at base, the apex dilated into a dark brown paddle-like blade; inner pleural appendage with the apical half considerably narrower than the basal half and provided with numerous tiny setæ. Gonapophyses complex, each side with three spines; the most cephalic of these is the smallest and very slender; the second spine is a powerful horn directed proximad, lying immediately caudad of the basal spine; besides these there is an elongate spine on either side of the penis-guard, directed caudad, gradually narrowed to the tip. Penis-guard very small and weak.

Hab. New Zealand (South Island). *Holotype*, ♂, Otatara, Otago, November 25, 1906 (*A. Philpott*).

Gynoplistia spinigera, sp. n.

General coloration light gray; antennæ of male 17-segmented; wings sybhyaline, the pattern almost obliterated; stigma distinct; abdomen light brown with a subterminal black ring; penis-guard with conspicuous serrations before the apex. *Male.*—Length 11 mm.; wing 10 mm.

Rostrum light gray; palpi broken. Antennæ brown, the first scapal segment slightly dusted with gray; basal flagellar segment paler on basal half; antennæ 17-segmented, the formula being 2+2+9+4, the longest flabellation about four times the segment; eleventh flagellar segment with only a tiny protuberance and may not be considered pectinate by some, in which case the formula would be 2+2+8+5. Head light gray with a U-shaped mark on the vertex, the arms becoming evanescent behind.

Pronotum light gray. Mesonotal præscutum gray with four rust-brown stripes, the intermediate pair becoming obsolete behind, being replaced by the ground-color; lateral stripes much broader; humeral region darker gray; pseudosutural foveæ very large, deep reddish brown; scutum gray medially, the centers of the lobes darker; scutellum destroyed by pin; postnotum gray. Pleura pale reddish brown, dusted with gray. Halteres broken. Legs with the coxæ pale reddish brown, dusted with gray; trochanters yellow; femora and tibiæ brown, pale ring on femora almost obliterated; tarsi dark brown. Wings subhyaline, the pattern very reduced; cells *C* and *Sc* very pale brown; stigma conspicuous dark brown; a small brown cloud at basal deflection of R_{4+5}; very indistinct brown seams at origin of *Rs;* along the cord; a small, faint cloud at outer end of vein Cu_2 and another on vein *1st A* immediately above the end of vein *2nd A;* wing-tip clear; veins brown.

Venation: Sc_1 ending opposite one-fourth R_{2+3}, Sc_2 reduced to a point by the downward bending of *Sc;* *Rs* long, strongly arcuated at origin, in alignment with R_{2+3} which, in turn, is in alignment with R_3; r near midlength of R_2; *r-m* reduced, about equal to, or shorter than, *m;* petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 near midlength of the cell.

Abdominal segments light brown, the basal tergite dusted with gray; a small, circular, darker brown median spot on each tergite; seventh segment black; hypopygium light brown. Male hypopygium with the ninth tergite broad at base, narrowed distally, the apex with a broad V-shaped notch. Pleurites comparatively slender, the apex a little produced; a small, cylindrical lobe on proximal face at base; outer pleural appendage angularly bent just before midlength, the tip very obtusely rounded and here microscopically spinulose; two small spines immediately before the apex; inner pleural appendage smaller, the proximal face beyond midlength slightly notched. Gonapophyses not developed. Penis-guard long and straight, the apex slightly curved, before the tip the lateral margins of the guard with conspicuous serrations.

Hab. New Zealand (South Island). *Holotype*, ♂, West Plains, Otago, November 5, 1900. (*A. Philpott*).

Gynoplistia cladophora, sp. n.

General coloration shiny black; antennæ of male 16-segmented; wings with a faint yellow tinge; cell *Sc* dark brown; wing-pattern very restricted; abdomen dark reddish brown, shiny; gonapophyses of male hypopygium widely separated, each appearing as a slender curved horn that bears a small lateral spine near midlength. *Male.*—Length 9 mm.; wing 9.2 mm.

Rostrum black, bearing a conspicuous brush of long, yellow hairs; mouthparts and palpi black. Antennæ black, 16-segmented, the formula being 2+2+10+2; longest flabellation about seven times as long as the segment that bears it; pectination of twelfth segment shorter than the segment; terminal flagellar segment larger than the others. Head rather dull black.

Pronotum with a grayish yellow pubescence medially, shiny reddish laterally. Mesonotal præscutum shiny reddish laterally, with a sparse microscopic pubescence, the entire disk occupied by three confluent shiny black stripes; scutal lobes likewise largely shiny black, the remainder brown; scutellum brown; postnotum brown basally, shiny black on the posterior half; lateral sclerites of postnotum reddish brown. Pleura dark liver-brown, sparsely pubescent, most conspicuous on the mesepisternum. Halteres yellow. Legs with the coxæ dark brown; trochanters slightly paler brown; femora brown, the tips dark brown; tibiæ and tarsi black; legs comparatively short and stout.

Wings with a faint yellowish tinge; cells *Sc*, Sc_1 and a seam along vein *Cu* dark brown; stigma dark brown, continued caudad as a comparatively narrow seam along the deflection of R_{4+5}; cord, outer end of cell *1st* M_2 and most of the longitudinal veins very narrowly and indistinctly seamed with pale brown; a quadrangular brown area at origin of *Rs*, this not attaining *M*; wing-tip scarcely darkened; veins dark brown. Venation: Sc_1 ending just before the end of *Rs*, Sc_1 about twice Sc_2; *Rs* very long, angulated and spurred at origin; R_{2+3} short, about equal to or shorter than *r-m*; *r* at about two-thirds R_2; cell R_2 very wide at outer margin; inner ends of cells R_4 and *1st* M_2 proximad of inner end of cell R_5; petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Abdominal tergites shiny, dark reddish brown, the lateral margins more blackened. Hypopygium with the pleurites short and stout; a short spine on proximal margin at base; distal ends of pleurites produced caudad into a flattened, obtuse lobe that is about one-half the length of the pleural appendage; outer pleural appendage stout, flattened, with a conspicuous notch before the tip; inner pleural appendage subequal in length but more slender, gently curved. Gonapophyses very complicated in structure, widely separated from one another, each side appearing as a long, slender, curved horn that bears a small lateral spine near midlength; the long, curved apex is directed laterad, thence proximad and caudad, almost in a circle. Penis-guard small and slender.

Hab. New Zealand (South Island). *Holotype*, ♂, Bluff, Otago, November 29, 1914 (*A. Philpott*).

Gynoplistia spinicalcar, sp. n.

General coloration shiny yellowish brown; head coal-black; tibial spurs flattened, the margins microscopically serrulate; wings nearly hyaline, rather heavily marked with brown; a brown spot at the base of cells *R* and *M*. *Female.*—Length about 12 mm.; wing 8.3 mm.

Rostrum and palpi dark brownish black. Antennæ with the scapal segments reddish fulvous; flagellum broken. Head shiny coal-black.

Pronotum black dorso-medially, obscure yellowish laterally. Mesonotum shiny yellowish brown without well-defined markings; scutum shiny yellow. Pleura dark brown, the mesepisternum with an area of appressed, silvery-white pubescence. Halteres yellow, the knobs brown. Legs with the coxæ and trochanters yellow; femora yellowish testaceous, the dilated apices conspicuously and extensively blackened; tibiæ dark brown, the tips blackened; tarsi black; hind legs missing; tibial spurs flattened, narrowed basally, slightly enlarged distally and with the margin microscopically serrulate. Wings nearly hyaline; cell Sc_1, except the outer end, dark brown; a large brown blotch at origin of *Rs*, extending from *R* to *M*; stigma dark brown, the color continued caudad along the cord as a very broad seam that continues across the

wing, cell Cu_1 being dark except at the outer anterior angle; cell *1st* M_2 with a circular hyaline centre; wing-tip in cells R_2 to M_3 narrowly darkened; a conspicuous brown cloud at the end of vein *2nd A* including the adjoining parts of cells *Cu*, *1st A* and *2nd A;* a conspicuous, oval, brown spot at the origin of *M*, almost equally distributed in cells *R* and *M;* veins dark brownish black. Venation: Sc_2 at tip of Sc_1 and much exceeding it in length; *Rs* gently arcuated at origin; R_{2+3} shorter than *r-m;* R_2 almost perpendicular at origin; *r* near tip of R_1; petiole of cell M_1 about as long as the cell; cell *1st* M_2 rectangular, the basal deflection of Cu_1 just beyond one-third its length.

Abdomen with the basal tergites greenish black; remaining tergites brown with blue and purple reflexions; sternites lighter brown. Ovipositor reddish horn-color, the valves very long and slender.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 feet, March 1, 1919, (*T. Harris*).

The type of *Gynoplistia spinicalcar* was sent to Mr. Edwards for comparison with his numerous types of New Zealand Gynoplistiæ. He writes "Closely allied to *G. tridactyla* Edw. and *G. speciosa* Edw. but I think certainly distinct. Note the peculiar spurs of the middle tibiæ which are quite similar in the two species mentioned."

Gynoplistia harrisi, sp. n.

General coloration of mesonotum shiny brownish yellow; pleura shiny black, including the posterior and middle coxæ; legs orange, the femora with a conspicuous, dark brown, subterminal ring; wings with a strong yellowish tinge and a heavy brown pattern; cell R_2 sessile; abdominal tergites shiny obscure yellow, segments six to eight metallic purple. *Female.*—Length 8 mm.; wing 8 mm.

Rostrum obscure yellow; palpi dark brown. Antennæ with apparently only 14 segments, all flagellar segments, except the terminal four, pectinate; terminal flagellar segment enlarged, apparently formed by the fusion of two segments; scapal segments obscure chestnut-brown; flagellar segments one and two obscure yellow, the pectinations dark brown; remainder of the antennæ dark brown Head obscure brownish yellow, somewhat darker between the eyes.

Pronotum obscure yellow. Mesonotal præscutum shiny brownish yellow with an indistinct, median, brownish black line; remainder of mesonotum shiny brownish yellow. Pleura shiny brownish black. Halteres short, pale, the large knobs darker. Legs with the posterior and middle coxæ shiny brownish black; fore coxæ obscure yellow; trochanters yellow; femora yellow with a narrow but conspicuous, subterminal, dark brown ring; tibiæ obscure yellow; posterior tibiæ

brown with the bases and tips paler; metatarsi obscure yellow, the terminal tarsal segments dark brown; the posterior legs are longer than the others, the femora somewhat swollen, the tibiæ more or less curved and only the terminal two tarsal segments infuscated. Wings with a strong yellowish tinge, brightest in cells *C*, *Sc* and *2nd A;* a conspicuous brown pattern distributed as follows: a brown area in the base of cell *R;* a large, quadrate area at origin of *Rs* that barely reaches *M;* the broad stigmal area extends as a solid block to cell *1st* M_2 where it splits, the center of the cell being of the ground-color; wing-tip broadly pale brown, including the apices of cells R_2, R_3, R_5, M_1 and *2nd* M_2; a conspicuous brown cloud in cells *Cu* and *1st A* at the end of vein *2nd A;* veins dark brown, more flavous in the yellow areas; microtrichiæ abundant in all cells beyond cord; in the radial cell they are practically lacking outside of the darkened areas. Venation: Sc_1 ending just before the tip of *Rs*, Sc_2 faint, at the tip of Sc_1; *Rs* long, feebly angulated at origin; cell R_2 sessile, the petiole entirely lacking; *r* close to tip of R_1; *r-m* very short, the deflections of R_{4+5} and M_{1+2} being correspondingly longer; petiole of cell M_1 a little shorter than the cell; basal deflection of Cu_1 at midlength of cell *1st* M_2.

Abdominal tergites shiny obscure yellow; segments six to eight metallic purple; lateral margins of tergites narrowly blackened; ninth segment and ovipositor orange; basal sternites obscure yellow; subterminal segments dark. Ovipositor with the valves very long and slender, straight.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 ft., February, 1920. (*T. Harris*).

Gynoplistia harrisi is a very distinct species of the genus. It is dedicated to the collector, Mr. Thomas R. Harris.

Gynoplistia unimaculata, sp. n.

Allied to *G. cuprea* Hutton; a conspicuous, slender tubercle on lateral sclerite of mesonotal postnotum; wings yellow, unmarked except for the dark brown stigma; abdomen with the basal tergite purple, segments two to six orange-yellow. *Sex?*—Wing 12 mm. Head destroyed by insect pests.

Mesonotum shiny reddish brown. Pleura reddish brown, the mesepisternum and dorsal parts of the mesosternum with a golden-yellow pollen; ventral portions of the mesosternum with metallic purple reflexions; lateral sclerites of postnotum immediately cephalad of the base of the halteres with a conspicuous, slender tubercle, directed laterad and slightly caudad. Halteres yellowish ochreous. Legs with the coxæ and trochanters reddish brown; femora light orange; tibiæ dark brown, the extreme base paler; tarsi dark brown. Wings with a strong brownish yellow tinge, clearer yellow in the costal region and the cells basad of the origin of *Rs;* no markings on the wing except the conspicuous, dark brown stigma; veins dark brown, more yellowish in

the flavous areas. Venation: Sc_1 ending beyond the fork of *Rs*, Sc_2 longer than Sc_1; R_{2+3} shorter than the deflection of R_{4+5}.

Abdomen with the basal tergite brilliant, dark metallic purple; segments two to six conspicuous orange-yellow with very faint purplish tints on the sternites; no trace of the coppery tints of *G. cuprea*.

Hab. New Zealand. *Holotype*, Sex?, exact locality unknown (Received from Dr. Campbell).

Although the unique type of this species is in poor condition, there can be no question of its specific validity. The almost unicolorous yellow wings with the stigma dark brown render the fly a conspicuous one.

Gynoplistia splendens, sp. n.

General coloration shiny reddish brown; antennæ 19-segmented; mesopleura with a patch of golden-yellow hairs; a conspicuous tubercle on mesepimeron; femora fulvous; wings bright yellow, marked with brown, including a broad apical and caudal margin. *Female.*—Length about 19 mm.; wing 15.5 mm.

Rostrum shiny yellowish brown; palpi dark brown. Antennæ dark brown; antennæ 19-segmented, the formula being 2+2+9+6; the twelfth flagellar segment bears a small lateral tubercle that is shorter than the segment but which might be considered as being a pectination, in which case the formula would be 2+2+10+5; longest flagellar pectination between three and four times as long as the segment. Head shiny brownish red, black between the eyes.

Pronotum dark reddish brown. Mesonotum shiny reddish brown, the median area of the præscutum almost black; median sclerite of postnotum paler laterally. Pleura dark chestnut brown with an extensive area of short, dense, appressed, golden-yellow hairs on mesepisternum and cephalic margin of mesepimeron; dorsal margin of mesepimeron, immediately beneath the wing-root, produced laterad and caudad into a stout, conspicuous tubercle. Halteres dark brown, the knobs conspicuously orange-yellow. Legs with the coxæ and trochanters dark chestnut-brown; femora rich fulvous, the tips narrowly blackened; fore tibiæ brown, the tips dark brown; mid-tibiæ reddish brown, near midlength passing into dark brown; posterior tibiæ fulvous, concolorous with femora, only the tips narrowly blackened; tarsi black. Wings bright yellow with a rather extensive brown pattern; a large spot at origin of *Rs*, barely confluent with the proximal end of a conspicuous brown seam along the distal half of vein *M;* the stigmal area includes the outer end of cell *Sc*, base of Sc_1 and a broad seam along the cord and outer end of cell *1st* M_2; wing-tip broadly and conspicuously infuscated, extending from cell R_2 to the end of *2nd A*, in cell *1st A* continued basad along vein *1st A* to beyond one-third the length of the

vein; vein *Cu* narrowly seamed with dark brown. Venation: Sc_2 much longer than Sc_1; *r* at tip of R_1; R_{2+3} shorter than *r-m;* petiole of cell M_1 about two-thirds the cell; basal deflection of Cu_1 just before midlength of the cell.

Abdomen shiny dark brown with conspicuous coppery and purple reflections as in the *cuprea* group. Ovipositor with the valves gently upcurved, reddish horn-color.

Hab. New Zealand (North Island). *Holotype*, ♀, Ohakune, altitude 2018 feet, February 15, 1920 (*T. Harris*).

Gynoplistia splendens belongs to the *cuprea* group. The unique type was submitted to Mr. Edwards who has kindly compared it with related species in the British Museum. He writes "Rather near *tuberculata* Edw. and *cuprea* Hutton but equally distinct from both." The collector states that this fly mimics a Hymenopterous insect, determined by the British Museum authorities as *Prionocnemis wakefieldi* Kirby.

Macromastix flavoscapus sp. n.

General coloration light yellow, including the frontal prolongation of the head and the first scapal segment; mesonotal præscutum with three brownish black stripes, the median stripe ending near midlength of the sclerite; each scutal lobe with two brownish black spots; a small spot on each side of scutellum; pleura yellow, in some cases with a small spot above the fore coxa and middle coxa; wings subhyaline, the costal region and stigma brownish black; wing-tip narrowly darkened; abdomen yellow, the tergites with three narrow black stripes. *Male.*—Length 12.5 mm.; wing 18 mm.

Female.—Length 12 mm.; wing 18.5 mm.

Frontal prolongation of the head entirely light yellow, only the tip of the slender nasus a little darkened; palpi black. Antennæ short in both sexes; first scapal segment entirely light yellow; remainder of antennæ black. Head light yellow, unmarked.

Pronotum yellow, unmarked. Mesonotal præscutum orange-yellow with three brownish black stripes, the lateral stripes remote from the median stripe, the latter tending to be evanescent behind, always indicated on the anterior half of sclerite, replaced by deep orange posteriorly; scutum yellow, each lobe with two black areas, the largest lying more proximad and caudad; scutellum orange-yellow with a small black spot on the caudal margin on either side of the median lobe; postnotum orange-yellow. Pleura orange-yellow; in some cases a small black spot above the fore and one above the mid-coxa. Halteres brown, the extreme base of the stem yellow, the knobs darker brown. Legs with

the coxæ orange-yellow; hind and mid trochanters brownish black; fore trochanters yellow with a black spot on the lower face; remainder of the legs black, the fore femora narrowly yellow basally. Wings nearly hyaline, the extreme tip clouded with darker; cells *C*, *Sc* and the stigma dark brownish black; veins black. Venation: *r* present; petiole of cell M_1 variable in length, sometimes longer than *r-m*, in some cases entirely lacking.

Abdomen light yellow, the tergites with three narrow black longitudinal stripes, the median stripe narrower than the yellow sublateral stripes; caudal margin of tergite seven and all of segments eight and nine black; sternites with a narrow median stripe.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*). *Allotopotype*, ♀. *Paratopotype*, ♂.

Macromastix atroflava, sp. n.

General coloration orange-yellow; antennæ and palpi black; a capillary black line on vertex; mesonotal præscutum with three stripes; legs black, the coxæ and trochanters orange; wings subhyaline, the costal region and stigma dark brown; abdomen yellow, the tergites with three, narrow, black, longitudinal stripes. *Male.*—Length 11.5–12 mm.; wing 16 mm. *Female.*—Length 11 mm.; wing 14 mm.

Frontal prolongation of the head yellow, the nasus and a linear triangle behind it, black; palpi black. Antennæ dark brownish black throughout. Head yellow with an elongate, capillary dark brown streak on vertex.

Pronotum entirely light yellow. Mesonotal præscutum orange-yellow with three conspicuous black stripes that are narrowly margined with brown; in the paratype, and less distinctly in the allotype, the stripes are entirely black; median stripe narrowed behind, not attaining the suture; lateral stripes narrower, crossing the suture and suffusing the lateral margins of the scutal lobes; remainder of mesonotum orange-yellow, immaculate. Pleura orange-yellow, immaculate, the dorso-pleural region light yellow. Halteres dark brown, the base of the stem narrowly orange. Legs with the coxæ and trochanters orange; remainder of legs black. Wings subhyaline, the costal region and stigma dark brown, this including cells *C*, *Sc*, Sc_1 and the stigma; wing-tip, in cells R_2, R_3, and R_5 very indistinctly darkened; veins dark brown, slender. Venation: *Rs* about one-third longer than R_{2+3}; petiole of cell M_1 very short, about equal to or a little longer than, *r;* basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Abdomen yellow, the basal tergite orange, the caudal margin of the other tergites except the last two, narrowly orange; tergites narrowly trilineate with black, the broad, yellow, sublateral stripes from two to three times as wide as the mid-dorsal black stripe; segments eight and nine black.

Hab. New Zealand (South Island). *Holotype*, ♂, Blackball, West Coast, December 1916 (*J. W. Campbell*). *Allotopotype*, ♀, December, 1917. *Paratopotype*, Sex?, with the type.

Macromastix lunata fuscolatera, subsp. n.

Female.—Length about 12 mm.; wing 16.5 mm.

In general appearance, very similar to *M. lunata* Hutton, differing as follows:

Head and thorax with the erect, pale hairs much less conspicuous than in *lunata*, these being short and subappressed.

Head dark brown, the lateral margins of the vertex adjoining the eyes broadly ochreous. Mesonotal præscutum light gray with three distinct, dark brown stripes, the broad median stripe narrowly split by a capillary pale line; scutal lobes with dark centers; remainder of mesonotum and the pleura light gray. Legs with the coxæ gray; trochanters yellow; femora and tibiæ light yellowish brown, the tips dark; tarsi dark brown. Wings brown, the stigma darker; wing-tip entirely dark; an interrupted subhyaline, lunate band in cell *M*, the proximal end barely extending into cell *R*, the distal end occupying the outer end of cell *R*, this subhyaline band narrowly interrupted across cell *M;* cell R_2 clear except the extreme outer angle; basal half of cell R_3 subhyaline; bases of cells *Cu*, *1st A* and *2nd A* pale. Venation: cell *2nd A* narrower than in *lunata*.

Abdomen with the four basal tergites dull rufous, with three very broad and conspicuous blackish stripes; extreme lateral margins of these tergites, and the succeeding segments, dusted with gray, more whitish on the lateral margins of tergites five and six. In typical *lunata*, the erect setæ on the head and thorax are much more conspicuous; basal abdominal tergites unmarked except medially; basal half of tergite two clear gray, in marked contrast to the posterior half and the other basal tergites. I have before me one of Hutton's paratypes of *lunata*, through the kindness of Mr. R. Speight. It is possible that the male of this species will be found to have short antennæ, in which case the form would take full specific rank.

Hab. New Zealand (North Island). *Holotype*, ♀, Mt. Ruapehu, alpine zone, 4000–5000 feet, January, 1921 (*M. N. Watt*). "In thick bush."

Macromastix intermedia, sp. n.

General color gray, the præscutum with four brown stripes; wings comparatively long and narrow, dark brown, with a subhyaline vitta extending from before midlength of the wing in cells *R* and *M*, through the bases of cells R_2 and R_3 to the margin, narrowly interrupted along the cord; cells M_1, *2nd* M_2

and M_3 pale; abdomen beyond the basal segment dark grayish brown throughout. *Male.*—Length about 9 mm.; wing 14 mm.

Frontal prolongation of the head gray, more brownish laterally; nasus very long; palpi dark brown. Antennæ very short, brown. Head grayish brown, paler gray adjoining the inner margin of the eyes.

Mesonotal præscutum gray with four brown stripes, the intermediate pair only narrowly separated by a capillary line; scutum pale buff, each lobe with a brown discal area; scutellum and postnotum pale buff. Pleura gray. Halteres dark brown. Legs with the coxæ gray; trochanters brownish yellow; remainder of the legs broken. Wings comparatively long and narrow, more than four and one-half times as long as wide; dark brown with a conspicuous, subhyaline, vittate pattern, this appearing as a lunate area in the outer end of cell *M*, including also the distal end of *R* and the proximal end of *1st* M_2; bases of cells R_2 and R_3 rather narrowly pale; cells M_1, *2nd* M_2 and M_3 and the bases of cells *Cu*, *1st* A and *2nd A* are much paler than the ground-color; veins dark brown. Venation: Basal section of M_{3+4} subequal to basal section of M_{1+2}; petiole of cell M_1 about equal to *m;* cells M_1, *2nd* M_2, M_3 and Cu_1 deeper than in *M. alexanderi* Edw.; cell *2nd A* narrower than in *alexanderi* but wider than in *M. vittata* Edw.

Abdomen dark grayish brown throughout, only the basal tergite a little paler; ninth tergite of male hypopygium with a deep notch.

Hab. New Zealand. *Holotype*, ♂, exact locality unknown (*J. W. Campbell*).

Macromastix hudsoniana, sp. n.

Size small (wing of ♂ under 10 mm.); antennæ of male longer than body; general coloration pale brown, the præscutum quadrivittate with darker brown; thorax without conspicuous erect setæ; wings with a brown tinge, cells *C*, *Sc* and the stigma darker brown. *Male.*—Length 7 mm.; wing 9.5 mm.; antenna 10 mm.

Frontal prolongation of head brown; palpi dark brown. Antennæ of male elongate, greatly exceeding the body, dark brownish black throughout; first flagellar segment a little longer than the combined scapal segments, only indistinctly separated from the second flagellar segment; flagellar segments beyond the third gradually decreasing in length, the last segment very small, subglobular; flagellar segments six to nine each with a pair of long, verticillate bristles immediately before midlength. Head brown, more grayish adjoining the inner margin of the eyes.

Mesonotal præscutum pale brownish testaceous with four darker brown stripes; scutum similar, the lobes darker brown; scutellum and postnotum brownish testaceous; mesonotum subglabrous. Pleura pale

grayish pruinose. Halteres brown, the knobs a little darker. Legs with the coxæ and trochanters brown; femora, tibiæ and metatarsi light brown, the tips dark brown; remainder of tarsi dark brown. Wings with a strong brown tinge; cells *C* and *Sc*, and the stigma, darker brown; veins dark brown. Venation: *Rs* rather long, about one-third longer than R_{2+3}; basal section of R_2 about one-third the distal section; petiole of cell M_1 longer than the cell; basal deflection of Cu_1 fused with *M* at about two-fifths the length of cell *1st* M_2; cell *2nd A* comparatively narrow.

Abdomen uniformly dark brown, the hypopygium and preceding segment brighter.

Hab. New Zealand (South Island). *Holotype*, ♂, Port Hills, Banks Peninsula, Canterbury, February 8, 1917.

Macromastix hudsoniana is distinguished from all described species by the combination of small size, subglabrous thorax and elongate male antennæ. It is named in honor of the veteran student of New Zealand Tipulidæ, George V. Hudson to whom I am indebted for many favors.

THE SYRPHID GENERA HAMMERSCHMIDTIA AND BRACHYOPA IN CANADA.

By C. Howard Curran,
Orillia, Ontario.

In presenting the present paper the author must offer apologies for its evident incompleteness, as it has been found impossible in the short time available to complete the drawings so necessary to illustrate the distinctive characters in a genus which is evidently somewhat confusing. A paper on the genus *Sphegina* was practically completed, with the necessary drawings, when it was learned that Dr. C. L. Metcalf already had a paper prepared on this genus, and it was therefore decided to review the genera indicated in the title, in so far as they are known in North America, with especial reference to the Canadian species.

According to my observations it is essential, in dealing with the majority of genera of *Syrphidæ* which occur in Canada, to include practically all the North American species, in any discussion which relates to their classification. For this reason the scope of the present paper is larger than the title may indicate.

Both *Hammerschmidtia* and *Brachyopa*, as genera, cannot be looked upon as well represented in most collections, although it seems that none of the species can be regarded as actually rare, and are, with the exception of *B. gigas*, probably of general distribution, and occur over the greater part of the United States and Canada. In Ontario I have records of six species of *Brachyopa* and one species of *Hammerschmidtia*. While the genitalia are not discussed in the present paper, they have been studied, and in every case bear out the apparent specific limitations.

Brachyopa Meigen.

Medium sized flies; head narrower than the thorax; face moderately produced downwards and forwards, concave, not tuberculate; antennæ short, third joint oval, rarely more roundish; arista basal, bare, pubescent or short plumose; eyes touching for a greater or less distance, bare; front in female narrowed above. Thorax a little narrowed in front, usually with some stouter hairs on the meospleuræ

above, on the postalar callosities and on the margin of the scutellum, which is rather large, squarish or more or less triangular. Abdomen roughly triangular in shape, broader, and not much longer than the thorax, broadest at the second segment, thence quickly narrowing to the apex, but less so in the female. Legs simple, the femora a little strengthened, and usually with short bristles below, especially the hind pair. Wings longer than the abdomen, anterior cross-vein before the middle of the discal cell, first posterior cell ending in an acute angle near the apex of the wing. Squamæ of medium size.

GENERIC RELATIONSHIP AND LIMITATION.

It seems that this genus cannot really claim close relationship to other genera found in North America, although certain characters indicate a common origin with several genera. In Europe it is even more isolated. I cannot agree that *Hammerschmidtia* is very closely related, because in that genus the wing venation is quite distinct, the face bears a distinct tubercle in the male, the tibiæ are all armed with spines, as are the femora, and the thorax and scutellum bear strong bristles. The fact that both may possess plumose arista does not constitute a close affinity.

It is perhaps as well to clear up the question of these two genera here. I would distinguish between them as follows: In *Hammerschmidtia* the abdomen is slender, twice as long as the thorax; the face is tuberculate in the male; thorax armed with very evident spines; the legs are armed with spines and the anterior four tibiæ terminate in a row of bristles; the first posterior cell is not acute, and ends well from the apex of the wing. In *Brachyopa* the abdomen is triangular, only a little longer than the thorax, the face is concave in both sexes, the thorax has sometimes very small bristles, the legs may have spines below the femora, but not elsewhere; the first posterior cell is acute and ends near the apex of the wing. Thus it will be seen that even leaving the plumosity of the arista out of consideration, there are ample grounds for separating the two genera.

The genus which appears to be most closely allied to *Brachyopa* is *Chalcomyia*, notwithstanding the separated eyes in the latter genus. The shape of the abdomen is very similar, the eyes of several species of *Brachyopa* are not actually contiguous, the facial profile is more similar, and the wing venation is identical. Moreover, I have taken representatives of both

genera together, and both occur early in the season. *Myiolepta* is probably closer to *Brachyopa* than is *Hammerschmidtia*, as is demonstrated by the maculation of the wings, the venation, and the facial profile of the females, but it differs in having the slender abdomen, as in *Hammerschmidtia*, except in *M. bella* Will., from the Pacific coast.

BIOLOGY.

I have not observed the immature stages of any species of *Brachyopa*, but according to Lundbeck, they are fairly well known. In Diptera Danica, part v, pp. 386-7, Lundbeck deals extensively with what had previously been published regarding the developmental stages. The conclusion arrived at (and bearing his own observations) is as follows: That the larvæ live in sap exuding from trees; the eggs are laid in the spring of the year, and the larvæ pass the summer feeding upon the sap, and hibernate in the autumn; pupation takes place in the spring, and the life cycle is completed with the emergence of the adult; there is only one brood. That this applies to the American species is borne out by what has already been published on the subject, and also by my own observations regarding the occurrence of the flies.

HABITAT AND HABITS OF THE ADULTS.

Both Verrall (British Flies, Vol. VIII) and Lundbeck state that the adults occur about exuding sap, upon which they apparently feed. While I have never observed them in such places I must say that the woods in which I found them so abundant in 1921 was in process of extermination, and hundreds of tree trunks were exuding sap. Muscids were swarming around these when I examined them in April in the hope of finding *Merapioidus villosus*. Also in the other woods where I took specimens many trees had exuding sap.

The species of *Brachyopa* all occur early in the season and specimens taken after the middle of June in Ontario must be looked upon as unusual captures. During 1921 I was able to do considerable collecting during May and June, and collected on Wild Plum and several species of Wild Cherry for the first time, which resulted in many things new to me, including six species of *Brachyopa*, one of which proved to be undescribed. The first specimen was captured on May 4th,

and was teneral. It was taken on wild black cherry. I had observed several specimens on plum blossom in a neighbor's garden about a week earlier. It is therefore safe to say that specimens may be looked for from the time plum begins to bloom, until towards the latter part of June. Choke cherry bloom followed the black cherry, and while not as productive, a stray specimen was taken. The vast majority, however, were taken in open, sub-swampy woods on bloom of Asmorrhiza clatoni, and in a single hour I captured over forty specimens, including four species. Where they appeared from so suddenly I cannot imagine, as I had collected in the same spot for several days previously without a sign of one. This was in June, and by the 14th they had disappeared entirely, having been present for less than a week.

The adults are rather peculiar in habit, and invariably appear to arrive on a blossom from nowhere. Only one specimen was observed arriving on bloom and it appeared to fly quickly, and settle solidly at once and commence feeding. They are diligent feeders, and hence are usually easy to capture. Unlike *H. ferruginea*, they frequently are found high up on a tree.

DISTRIBUTION.

In Ontario I have taken six of the ten known species, and in view of the fact that some of these are recorded from the Pacific coast, while others are supposedly more or less southern, I conclude that all the species may be expected to occur at least in the northern States and Canada, with the exception that *B. gigas* Lovett probably occurs only in the Rockies and west. *B. media* was described from California, but occurs in Ontario, while *B. notata*, originally described from New Hampshire, occurs in British Columbia, Oregon and Washington Territory.

CHARACTERS USED IN CLASSIFICATION.

Several of the characters which might be used in classification are not employed here because they are often open to dispute and may cause confusion. One such character is the pilosity of the arista, which may vary somewhat in the same species, as is the case in the British Columbia specimen of *B. notata*, which has the pile distinctly longer than in any of the eastern specimens which are before me. While the structure of the

genitalia in the male is of great importance and of unusual value in this genus, as has been explained, they are not employed in the descriptions, as it is my belief that they must be demonstrated by means of drawings to be of greatest value, especially when the use of this character is still in its infancy.

The characters chiefly used are the color of the thorax and abdomen, and it may be safely said that this is sufficiently stable to permit of identification with certainty; and moreover, the structure of the hypopygia bears out the specific limitations in every case where I have males. I am therefore able to state that at present the only species of which there might be any doubt are *B. media*, *flavescens* and *rufiabdominalis*, all of which are closely related to *B. bicolor* of Europe. I do, however, believe the species mentioned above to be distinct, although one of the American species may be *B. bicolor*. Dr. Johnson* also remarked upon the constancy of the thoracic lines and abdominal coloration. It frequently happens that the terminal abdominal segments may appear darkened, but this is due to internal coloration and not to the pigmentation of the chitinous material.

TABLE OF SPECIES.

1. Second and third abdominal segments with posterior pollinose bands.....2.
   Second and third segments without such bands.....3.
2. Thorax with anterior median darker stripes and interrupted sublateral stripes; all the abdominal segments with roundish shining spots on each side. (Length about 5 mm.).....*cynops* Snow.
   †In addition to the stripes as in *cynops*, the thorax with a roundish spot at inner ends of the suture and a slightly oblique stripe on each side posteriorly, second and fourth segments entirely shining anteriorly, *diversa* Johns.
3. Abdomen entirely black.....*daeckei* Johns.
   Abdomen ferruginous, yellowish, or partly yellow.....4.
4. Last two or three segments shining black; second segment chiefly translucent yellowish.....*vacua* O. S.
   Abdomen not so maculated.....5.
5. Abdomen with median longitudinal stripe, interrupted before the sutures or entire; or arista distinctly plumose.....6.
   Abdomen without median longitudinal stripe.....8.
6. Thorax grayish black or slaty; abdomen luteous.....*perplexa* Curr.
   Thorax ferruginous or yellowish red.....7.
7. Thorax and abdomen ferruginous (about 10 mm.).....*gigas* Lovett
   Thorax more yellowish red, with lighter stripes; color of abdomen more clear yellow (8 mm.).....*notata* O. S.
8. Thorax reddish yellow; at any rate not at all blackish on the posterior half.....*flavescens* Shan.
   Thorax blackish.....9.
9. Eyes narrowly separated, most nearly contiguous near the ocelli, *rufiabdominalis* Jones
   Eyes distinctly contiguous, the vertical triangle long and narrow..*media* Will.

*Can. Ent., Vol. XLIX, p. 361, (1917).

†The character of most importance here is the color of the abdomen. Snow's description of thorax was incomplete.

Brachyopa cynops Snow.

Length 5 mm. Female. Head light yellowish brown, largely concealed beneath glistening pollen; the shining ground color shows just above the antennæ and in a stripe on the cheeks, extending from the eye to the mouth opening. Antennæ wanting. Dorsum of thorax brown, covered with grayish pollen, anteriorly with two approximated linear blackish stripes; laterally with a broad interrupted stripe. Scutellum light brown, with yellowish pollen. Abdomen but little longer than broad; yellowish gray pollinose; second segment with a circular brown spot on the anterior corners; the two following segments are marked with corresponding elliptical spots, and, in the middle anterior border with a triangular spot; on the fifth segment are two small round spots. Legs uniformly reddish brown, with light colored pollen and short whitish pile. Wing hyaline, distinctly clouded at anterior cross-vein, on the veins at the anterior outer corner of the discal cell and on the ultimate section of the fourth vein; posterior cross-vein about as long as the ultimate section of the fourth vein, the included angle obtuse. One specimen, Colorado. (Snow).

Snow does not state the sex, but the figure is that of a female; also the figure shows the posterior oblique stripes on the thorax as in *diversa*, but not the spot inside the suture.

Brachyopa diversa Johnson.

Abdomen with grayish yellow pollinose posterior bands, the second segment chiefly pollinose.

Length, 6 to 8 mm. Male. Face and front brownish red, covered with whitish pollen which leavse the oral margin in front, a spot above the antennæ and a stripe on the cheeks, shining brownish. Antennæ brownish red, the first joint darker, shining. Vertical triangle blackish, with short brown pile; posterior orbits brownish red, pollinose, with whitish pile. In profile the face is concave above, a little convex below, prominent below, and moderately produced downwards. Eyes practically touching, the vertical triangle long and narrow. Dorsum of thorax grayish pollinose, leaving shining brownish stripes as follows: a median pair on the anterior two-thirds, an interrupted stripe on each side of these, and the sides of the dorsum, a slender median one in front of the scutellum, slightly oblique ones running from the corners of the scutellum to just outside the ends of the antero-median stripes, and a spot on the inner ends of the suture. Pleuræ brownish red, with lighter pollen. Pile of the dorsum black, but with yellowish pile between the humeri and across the posterior margin; pleuræ with yellowish pile, a cluster of black hairs on the upper part of the mesopleuræ. Scutellum reddish, yellowish pilose, with a few longer, but not bristly hairs on the margin. Abdomen shining black, the first and second segments grayish yellow pollinose; second segment with a median longitudinal line, not reaching the posterior margin, and an oval spot, reaching the sides, on the anterior portion, shining black; third and fourth segments shining

black, with the hind margins grayish yellow pollinose, the pollen extending forward in the middle to the anterior third, but there is a roundish notch centrally in front, corresponding to the median stripe on the second segment. Hypopygium yellowish red. Abdomen with light yellow pile, longer basally. Legs black, anterior four trochanters, tips of the femora, the anterior ones beneath apically, basal third of tibiæ, tips of the tibiæ and tips of the tarsal joints, luteous or yellow. Wings slightly yellowish anteriorly, the veins all a little crowded, the region of the anterior cross vein and a streak between the spurious vein and the fourth vein beyond the cross-vein, brownish; wings more yellowish basally.

Female. Front golden yellow pollinose, leaving the ocelli and a streak in front shining black, a large area above the antennæ, cut off truncately above, and the face below, on the sides, shining yellowish, although the lower part of the face is slightly pubescent. The pollen on the thorax and abdomen is more yellow; fifth abdominal segment yellow pollinose, except an anterior broadly interrupted cross-band; third antennal joint broader, a little darker.

Description drawn from 9 specimens, taken at Orillia on May 5th to 18th, 1921.

This species is easily distinguished from the preceding by the less pollinose abdomen, as the anterior half of the median segments is wholly shining, whereas in *cynops* there are very distinct oval shining spots on the anterior angles, the balance of the segment being shining.

Brachyopa vacua O. S.

Abdomen with the second segment pallidly yellowish, the apical segments shining blackish.

Length, 7 to 9 mm. Male. Face and front of a dirty yellowish color, clothed with whitish pollen, which leaves a brown stripe on the cheeks and an area above the antennæ shining. Antennæ colored as the face, arista black, and almost bare. Vertical triangle long, the eyes touching for only a short distance, a distinct median groove in front of the ocellar triangle, which is brownish; occiput with grayish pollen and head with entirely pale pile. Dorsum of thorax obscured by grayish yellow pollen, which leaves the usual double median stripe, an interrupted stripe on each side and a spot above the wings, brownish. The pleuræ are ferruginous, the sternum blackish, but thickly whitish pollinose. Pile of thorax yellowish on the dorsum, whitish on pleuræ. Scutellum luteous yellow, subtranslucent, squarish, with short, white pile. First abdominal segment brown, the anterior angles yellowish, the whole whitish pollinose; second segment except the apical sixth, the lateral margin posteriorly and a median dash, usually not reaching the black posterior border, shining yellowish. The rest of the abdomen, except the small anterior angles of the third segment, which are yellowish, shining brownish black. Pile wholly white. Legs brownish, the femora thinly

whitish pollinose; coxæ, trochanters and bases of the femora narrowly, tips of the femora, bases of the tibiæ and their tips and the first one or two tarsal joints more or less yellowish or luteous. Hind femora a little produced beneath near the end. Wings a little darkened, yellowish basally.

Female. Similar. Front, except the shining yellowish area above the antennæ which is thinly whitish pollinose, brownish, and with reddish brown or grayish pollen. (Neither of my specimens have the front as light colored as indicated in Osten Sacken's description.) One male has the narrow, irregular anterior margin of the third abdominal segment yellow, and the thorax a little more brownish.

It is probable that the type specimen was teneral. The species was originally described from Quebec, but since that time, except for a single specimen recorded by Williston from California, it has apparently not been recorded. The above description is drawn from eight specimens taken at Orillia, May 4th to 30th, 1921.

This species cannot well be confused with any other in the genus.

Brachyopa daeckei Johnson.

"Length, 6 mm. Front black, grayish pollinose, a shining spot above the base of the antennæ, yellow, bordered with black; face below the antennæ grayish pollinose, sides shining, yellow, with two spots of black, antennæ dark yellow, arista brown. Thorax black, grayish pollinose, with five sub-shining lines, the three inner ones slightly diverging, but not reaching the scutellum. Pleuræ brownish grayish pollinose, scutellum brown, the apical half much lighter than the base. Abdomen black, shining, hairs white. Legs brown, hairs white, outer half of the posterior femora blackish, tarsi yellowish; halteres yellow. Wings hyaline, veins brown, stigma yellow, anterior cross-vein slightly clouded with brown, tegulæ white.

"One specimen, Castle Rock, Delaware County, Pa., May 19, 1902, collected by Mr. V. A. E. Daecke. This specimen has been referred to as a dark variety of *B. media* (Psyche, Vol. XVII, p. 230, 1910) but further study in connection with the following species convinces me that it is distinct." (Johnson).

Brachyopa rufiabdominalis Jones.

"Length, 7 mm. Face light reddish brown, prominently produced forward, with light, silvery, glistening pollen and very fine white pubescence; slightly concave beneath the antennæ; frontal triangle shining, prominent, with or without a median suture. Cheeks a little darker red than the face and with a shining stripe from the eye to the oral margin; sparsely covered with long white pile. Antennæ situated on a semi-conical projection, of the same general color as the face, but slightly darker; first joint about half as long as the second, of a slightly

deeper red than the third, dorsally, with a tuft of black hairs on each joint; third joint light red, about as long as the first two together, ovate; arista basal, bare. Vertex black, frontal portion with or without silvery pollen, eyes narrowly separated. Dorsum of thorax brown, with black pile, covered with grayish pollen, anteriorly with two approximate dorso-medial blackish stripes, laterally with a broad interrupted stripe; the transverse suture deep, shining; humeri with a reddish spot; pleuræ reddish brown; a reddish brown stripe extending from the scutellum to the base of the wing. Scutellum light reddish brown, beset with blackish and reddish pile, shining, with a very narrow median light stripe; abdomen slightly longer than the thorax, but little longer than wide, light reddish brown and entirely shining, with reddish pile; the posterior portions of segments one, two and three with a posterior shining, brownish, transverse band, either entire or interrupted in the middle. Legs of the same color as the abdomen, principally with light colored pile, on the under side of the hind femora and the apex of the anterior four femora with stout black pile; tarsi darker brown, light at apex; hind basitarsi slightly thickened at base and thence gradually tapering to apex. Wings hyaline with a reddish tinge, anterior cross-vein before the middle of the discal cell and almost rectangular. (Colorado). (Jones).

"*B. rufiabdominalis* differs from *B. cynops* in that the scutellum and abdomen are entirely shining, etc. Differs from *B. bicolor* of Europe in that the occiput of the latter is pale gray and with gray pile, the face is without pubescence, the eyes touch for about one-third the distance from the ocelli to the antennæ; the scutellum has eight long marginal hairs and is covered with short black pile, while in *rufiabdominalis* the occiput is black, whitish pollinose and has black and whitish pile; the face has fine whitish pubescence on it; the eyes are distinctly separated, the nearest point of contingency being immediately below the ocelli; the scutellum has black pile dorsally, and the remainder is covered with reddish pile and lacks the eight black marginal bristles." (Adapted from Jones). For further remarks see *B. media* Will.

Brachyopa media Will.

Small, dorsum of thorax blackish or slaty, abdomen reddish yellow, the hind borders of the segments narrowly brownish; front in female brownish.

Length, 6 to 7 mm. Male. Face and front reddish yellow, the cheeks and most of the frontal triangle shining, elsewhere whitish pollinose. Antennæ reddish yellow, arista black, its base reddish. Vertical triangle long, narrow, the eyes touching for only a short distance; occiput brownish above. Dorsum of thorax blackish or brownish black, the sides usually reddish, covered with whitish yellow pollen, leaving a median double stripe, and an interrupted stripe on each side, brownish; humeri yellowish; pleuræ reddish brown above, brownish below, thinly whitish pollinose. Scutellum reddish yellow. Pile of thorax and scutellum yellowish, on the pleuræ whitish. Abdomen

reddish yellow, more reddish apically; second, third and fourth segments and their lateral margins, except anteriorly, very narrowly brownish or reddish brown; pile short, yellowish. Legs yellowish, including the coxæ; hind tibiæ with a slightly darker pre-apical band; hind tarsi brownish. Wings very slightly darkened with luteous, the tip a little blackened.

Female. Face shining, except below the antennæ; front blackish above, whitish pubescent except a median longitudinal shining stripe connecting with the shining area above the antennæ; pollen of the thorax more whitish; wings almost hyaline; legs somewhat paler. Otherwise as in the male.

B. media was originally described from California from a single female specimen. I have before me a female from Teulon, Manitoba, May 15, 1920, and two males taken at Orillia, Ontario, on May 30, 1921.

The specimens described above agree perfectly with Williston's description and I consider them absolutely typical. *B. rufiabdominalis* agrees fairly well with the above description, but the color appears to be darker and the eyes are narrowly separated and approach each other near the ocelli which would make the vertical triangle short, while in *media* the vertical triangle is long and the eyes touch nearer the antennal base than the ocelli. The only other species which is really confusing is *flavescens*, which has a wholly pale thorax (Johnston says the thorax may be brown before the suture) and a yellowish front in the female. The face is also more concave. I believe these three species are abundantly distinct, but a large series of all the species, and a comparison of the male genitalia will be necessary to definitely determine this point. A comparison with *B. bicolor* is necessary. Strangely enough Jones did not even mention *media* in establishing his *B. rufiabdominalis*, which seems rather strange in view of the fact that only the female of the former had been described.

Brachyopa flavescens Shannon.

Thorax wholly reddish yellow (or brownish before the suture—Johnson); abdomen with narrow posterior segmental margins brownish.

Length, 3.75 to 6 mm. Female. Face, except below the antennæ, lower part of the front, and a slender median frontal stripe, shining reddish yellow; front yellow pollinose, face with whitish pollen except where shining. Occiput above darkish, with whitish pollen; face a little more concave than in *media*. Thorax wholly reddish yellow, with the usual stripes shining. Abdomen reddish yellow, the narrow posterior margins of the segments brownish, their lateral margins

very narrowly or obscurely brownish on their posterior half. Legs yellow; hind femora, sub-base and preapical band on hind tibiæ and the hind basitarsi and last segment, brownish or darkened. Wings hyaline.

"Male, rather robust, small, yellowish, eyes strongly contiguous; vertex yellowish gray, with pale, very short pile; vertical triangle narrow and acute, reaching forward to about the middle of the eyes; frontal triangle yellow, bare. Antennæ orange-yellow; third joint ovate, longer than broad; arista darkened distally and with very fine microscopic pubescence along its entire length. Face moderately produced, light yellow, dusted with white and with fine white hairs, the lower half produced and truncate, its upper angle slightly acute. Mesonotum dark ocher yellow, dusted with brownish gray, at the sides and behind, broadly ferruginous and more shining; two narrow and approximated stripes medianly on the anterior two-thirds, two broad, anteriorly and posteriorly abbreviated stripes outwardly, hairs rather short and dense, yellow. Pleuræ brown and black, thickly dusted with gray; mesopleuræ with somewhat longer hairs than those on mesonotum. Scutellum convex, broadly rounded, much broader than long, shining ocher yellow, rather evenly punctured, with light yellow hairs and a few bristle-like ones on the posterior margin. Abdomen much broader than thorax, broadest at posterior margin of second segment; color light yellow, more or less stained with dark by body contents; second segment more or less translucent. Coxæ yellow. Anterior and middle pairs of legs yellow, with white pile. Hind pair somewhat darker, the femora distally tinged with brown and with minute black spines along ventral surface; tibiæ tinged with brown on distal half; first tarsal joint grayish brown, paler distally and ventrally. Wings hyaline, faintly smoky, without trace of maculation, slightly darkened distally along anterior margin; stigma yellow. Halteres pale yellow." (Shannon).

The species has been sufficiently discussed under the preceding species. It has been reported from Fairfax County, Virginia, (type locality), Massachusetts and New Hampshire (Johnson), and I have two female specimens from Orillia, Ontario, taken by myself, May 5th and 21st, 1921. The description of the female given here is made from local specimens, while the description of the male is that of Shannon.

Brachyopa perplexa Curran.

Closely related to *B. notata*, but arista not as pubescent and epistoma more produced; larger than *B. media* and with black abdominal markings, and the median longitudinal black line practically complete.

Length, 6.5 to 8.5 mm. Male. Face and front pale yellow, thickly covered with white pollen, the cheeks and frontal triangle, except narrowly next to the eyes, shining; a brownish or ferruginous stripe from the eyes to the oral margin; occiput below shining ferruginous,

but above and near the eyes, grayish pubescent. The face is considerably produced downwards and forwards; in profile moderately concave from the antennal base to the prominent oral margin. Antennæ reddish yellow, third joint longer than broad, its lower end more pointed, not large, arista brownish, slightly noticeably pubescent. Vertical triangle and a narrow V on the occiput behind the ocelli, grayish yellow (sub-golden) pollinose, the ocellar triangle shining brown. Pile of the head: A few pale hairs on the cheeks, posterior orbits with long pale pile below, and short black pile arranged in definite rows above. Thorax reddish brown, the sternum more blackish, but covered with grayish pollen. Disc of the dorsum grayish pollinose, leaving four stripes of a dark reddish brown or blackish, the median ones very narrowly separated and expanded posteriorly to unite with the sublateral bands, which are also entire; the opaque area is strictly confined to the disc. A darker, thickly black pilose opaque stripe runs from the postalar callosity to the suture; dorsum of thorax with short black pile, the pleuræ with longer, white pile. Scutellum brownish yellow, with short black pile, with a few longer, bristle-like hairs apically. Abdomen: First segment black, its anterior border yellow; second segment pale yellow to slightly reddish yellow, with a median longitudinal black stripe narrowly separated from the anterior margin, and often joined to the black posterior margin or slightly separated from it (the mark is ! shaped, without the dot below); hind border narrowly black and sides of segment, except anteriorly, black; third segment similar, darker colored, but the median stripe entire and the lateral margins usually entirely blackish; fourth segment similar, but the lateral margins more brownish. Hypopygium yellowish red. Pile of abdomen fine, whitish, except on the apical half of segments two and three, where it is black. Legs reddish brown; tarsi all brown or blackish, except that the first three joints are yellow apically; hind femora darker on apical quarter; hind tibiæ darker, with a pale median band; anterior four tibiæ sometimes darker apically. Wings slightly yellowish tinged, stigma pale luteous. Squamæ clear white, with white pile. Halteres slightly yellowish. In somewhat teneral specimens taken in early May the abdominal markings are more brownish, and in fully mature specimens the abdomen may be more reddish, and is always wholly shining. The thorax may be slightly darker or paler than described.

Female. Averages .5 mm. smaller than the male. Face a little more deeply excavated; front shining ferruginous with a very narrowly interrupted whitish pollinose band below the middle; stripe on the cheeks only a little darker than facial color or concolorous; median abdominal stripe broader, complete on second, third and fourth segments; transverse bands broader and successively narrower apically; fifth segment yellowish ferruginous with the narrow hind border blackish and the lateral margins ferruginous or brownish. The general color is more ferruginous than in the male.

B. perplexa is evidently widely distributed, but it is impossible to state its distribution owing to its confusion with

media and *notata*. Altogether I took over sixty specimens at Orillia in 1921, between May 8th and June 14th. I have also specimens from Maine (C. W. Johnson).

B. perplexa differs from *notata* in shorter pile on arista, dark thorax and abdominal markings, paler general ground color, more produced face, and unclouded wings. It is at once distinguished from *media* by the presence of the median line. From *gigas* it is readily distinguished by its darker thorax, smaller size, and less pilose arista. Dr. Johnson had also this species before him when he discussed *B. media* (Can. Ent., Vol. XLIX, p. 362) as is quite evident from his remarks, and I have two males received from him, as *B. media*.

Brachyopa notata Osten Sacken.

Arista short plumose; thorax yellowish red; abdomen with an interrupted median stripe.

Length, 5.5 to 7 mm. Male. Face and front yellow, whitish pollinose, leaving the frontal triangle chiefly, and a broad stripe on the cheeks shining ferruginous. Antennæ reddish yellow, third joint elongate oval, more pointed below; arista reddish, short plumose; vertical triangle tinged with brownish, with very short brownish pile; eyes touching for almost the same length as the vertical triangle; posterior orbits dull yellow, with whitish pile Thorax yellowish red, thinly whitish pollinose, leaving a shining double median stripe and sub-lateral stripe, interrupted at the suture, and the margins of the dorsum, shining. Pile of dorsum black, but whitish between the humeri. Pleuræ with yellowish pile, the long hairs on the upper portion of the mesopleuræ may be more or less blackish, although usually all pale. Scutellum triangular, the apex rounded, lighter colored than the thorax, with black pile and some slightly longer marginal hairs. Abdomen yellow or reddish yellow; all the segments with a narrow brown posterior border, which is continued forward on the sides of the segments to near the anterior angles. In the middle, the second and third segments with a longitudinal dash of brown, not reaching the posterior brown margin; sometimes a small spot on the fourth segment. Pile of the abdomen pale yellowish, but black on the posterior half of segments two and three. Legs reddish yellow, the last two tarsal joints brown; anterior basitarsi, hind basitarsi with the two following joints, more brownish. Legs chiefly short stout pilose, the femora with stiff hairs below. Wings tinged with luteous or yellowish, the stigma luteous; a dark cloud follows the border of the wing from the stigma to the tip of the fourth vein, a distinct spot at the end of the fifth vein, and the region of all the veins dilutely clouded.

Female. Front only a little narrowed above, dull yellow; a large shining spot above the antennæ; ocellar triangle brownish; pile of front

brownish; third antennal joint oval, larger than in the male; markings on thorax more distinct; abdominal markings a little broader, the median stripes complete. Legs a little darker, wings with more distinct clouds.

In some specimens the terminal segments may appear brownish. This condition is not natural, but is caused by internal organs, or staining.

B. notata has been reported in Canada from Ottawa, Ont. I have a male before me from Ottawa, a male from Vancouver, B. C., a pair from Orono, Maine, and a pair from White Mountains, N. H. Likely to be confused only with *perplexa*, from which it is readily distinguished by its pale thorax, more distinctly maculated wings, etc. The male from British Columbia appears to be teneral, and the median stripes are very faint, practically wanting and the fourth segment has no brown hind margin, but the sides are narrowly brownish. The color is a little paler yellow, but darker than in most specimens of *flavescens*, from which it is readily distinguished by the larger scutellum and distinctly plumose arista.

Brachyopa gigas Lovett.

The largest known species in the genus; arista very distinctly plumose; thorax ferruginous yellowish; abdomen of same color, with four darker stripes.

Length, 10 mm. Male. Face and front yellow, whitish pollinose, the cheeks and the greater part of the frontal triangle, shining, darker; face produced downwards and forwards. Antennæ reddish yellow, third joint elongate oval, flattened above on the apical third or more, making the end appear more pointed below; arista brown, its base yellow, short, sparse plumose, but longer than in other species. Vertical triangle brown, with mixed yellow and brown pollen and short brown pile; occiput shining below, gray pollinose above, and with light colored pile. Eyes touching for moderate distance. Thorax ferruginous reddish, with a median double stripe and an interrupted stripe on each side, reaching quite to the scutellum, more brownish; a brown spot behind the front coxæ. Scutellum concolorous with thorax. Pile of the thorax and scutellum black, across the front between the humeri and the sides of the dorsum and corners of the scutellum with yellow pile. Abdomen ferruginous reddish, all the segments with brownish posterior margins, and the lateral margin entirely narrowly bordered with shining brown; second to fifth segments with an elongate median dash in front, brownish. Legs yellowish brownish, the last two tarsal joints brown. Wings yellowish in front, the stigma yellow.

Originally described from Washington State from a single male. According to Lovett and Cole there are several specimens

in the Collection of Washington State College. The above description is made from two specimens from British Columbia, and there are three specimens in the Canadian National Collection from British Columbia.

A very distinct species by its large size and rather distinctive color. The arista is most conspicuously plumose, and the species would be included in *Hammerschmidtia* in Europe.

Hammerschmidtia.

The characteristics of this genus have been sufficiently dealt with under *Brachyopa*. The species discussed below is the type of the genus, and possibly the only representative.

Hammerschmidtia ferruginea, Fallen.

Length, 9 to 11 mm. Male. Head yellowish red, antennal base, a median facial stripe and the cheeks shining; in profile a little excavated below the antennæ, and a little below the middle with a longish tubercle, below which it is slightly retreating to the oral opening, or the face may be more excavated below the antennæ; it is considerably produced downwards. Antennæ shining yellowish red, arista black, its base reddish, plumose. Pile of occiput wholly yellowish. Thorax brownish, sometimes ferruginous, the side margins always ferruginous reddish, on each side of the middle with rather broad, posteriorly abbreviated grayish or silvery pollinose stripes. The pile is chiefly short, pale yellowish, but there are some longer, black, stout hairs behind the suture and on the darker stripes. There are bristle-like hairs on the mesopleuræ, in front of the suture at the side, above the base of the wings, on the postalar calli and the apex of the scutellum, which is reddish, with short black pile. The abdomen is very variable in color, but seems to be chiefly shining brownish with quadrate reddish or ferruginous spots on the anterior angles, occupying about half the length of the segment, and broadly separated, in mature specimens; or the spots may occupy most of the segment and form a complete anterior band, or the second segment may be entirely ferruginous. The fourth segment is usually all brown, except the anterior corners, but may be only brownish posteriorly in light colored specimens. The hypopygium is always light reddish to reddish. The pile is very short, blackish, except basally, on the anterior angles of the segments and on the hypopygium, where it is whitish and longer. The legs show the same variation in color from ferruginous brown to ferruginous, the hind legs always darker; four anterior coxæ reddish or yellow; hind tibiæ arcuate and paler basally; last two tarsal joints blackish. All the femora, which are a little thickened, the hind ones more so, are armed with short black spines beneath and long black bristles posteriorly and anteriorly; the hind tibiæ bear several short, stout bristles exteriorly, and all the tibiæ, the hind ones less prominently so, bear a terminal

fringe of black spines. The veins are all more or less clouded, more marked anteriorly; stigma brownish yellow.

Female Facial tubercle practically wanting; front reddish, a little shining, a shallow median groove extending between the ocelli and antennal prominence; indistinctly finely wrinkled, especially above; thorax lighter colored; abdomen more yellowish red, the darker areas more restricted and more ferruginous; legs paler. Pigment of the wings more blackish, and a little more extensive anteriorly. Possibly there is as much variation as in the male.

This description is drawn from 9 males and 1 female taken by myself at Orillia, May 18th to 30th. The species has been reported from Manitoba, B. C., Washington, and other places and is probably to be found over the whole of Canada and the northern States.

I do not think that *H. ferruginea* can be classed as a rare species, but it is most certainly not common in collections. This is, I think, due to the fact that its habits are not well understood. While it is true that it occurs in company with *Brachyopa* spp., it seems to have slightly different habits generally. I have found it more often on very low blooms of choke cherry, that is about two or three feet from the ground, but I took one specimen on bloom about eight feet up, and another specimen was taken on bloom in open sub-swampy woods. Another peculiarity is that I have never seen the species flying before four o'clock in the afternoon, but this may be due to the fact that my collecting in May was practically all done after two-thirty P. M.

Since the above paper was prepared several additional specimens belonging to these two genera have been examined, including two additional new species.

Brachyopa cynops Snow.

I have examined the type of this species, and find it to be a female. The description covers all the essential points. The dorsum of the thorax is rusty yellow rather dull, the disc, occupying about half the width of the dorsum, black; the pollen is greyish yellow, not grey and the shining stripes are not distinct.

Brachyopa vacua O. S.

About thirty specimens from Kansas and Missouri show no differences from the description.

Brachyopa rufiabdominalis Jones.

Three specimens of this species from Washington State. The color of the thorax is more slaty than in *media*, the third antennal segment is longer and larger. In the female the front is a little wider, the sides less parallel, more evidently dusted on the black portion and therefore appearing lighter in color. The legs are all reddish, the tarsi brownish red. Abdomen wholly rusty reddish yellow. I could not see that the eyes of the male differed greatly from *media*, but the chief difference seems to be in the fact that the abdomen entirely lacks any darker lines on the apices of the segments, more slaty color of the thorax and slightly larger size. My three specimens are all between 7.5 and 8 mm.

Brachyopa notata O. S.

Five additional specimens from Washington State and Idaho. These agree with the specimen mentioned from British Columbia, and may be distinct. Two additional specimens from New York agree with the eastern specimens.

Brachyopa perplexa.

Two additional specimens from New York State agree perfectly.

Brachyopa gigas Lovett.

A specimen from Washington State and a second from Idaho.

Brachyopa basilaris n. sp.

This species traces out to *notata* in the key. It is distinguished by the wholly red first two abdominal segments, the remaining segments being black. Female from Washington State.

Brachyopa nigricauda n. sp.

Traces out to *dæckei* Johnson in the key. Distinguished from that species by the presence of six shining stripes on the dorsum of the thorac, more reddish pleuræ and humeri, more extensively yellow scutellum, yellowish wings and paler legs; the anterior tarsi are all blackish as are the two apical segments of the remaining tarsi.

The descriptions of these two species will be published in the Kansas University Science Bulletin during the current year.

I have also examined a male specimen of *Brachyopa bicolor* Fallen, from Europe and can say definitely that none of our North American species is conspecific.

A CONTRIBUTION TO THE KNOWLEDGE OF THE INTERNAL ANATOMY OF TRICHOPTERA.*

By Hazel Elisabeth Branch,
Wichita, Kansas.

NERVOUS SYSTEM.†

The nervous system of the trichopterous larvæ is comparatively primitive and agrees with that of the lepidopterous larvæ in the number of pairs of ganglia and also resembles, in some respects, the arrangement in relation to the body segments. Exclusive of the ganglia in the head, which are normal in number and position, there are three pairs for the thorax and eight pairs for the nine abdominal segments, the seventh abdominal segment being the most posterior in which ganglia are found.

In the head of ***Limnophilus indivisus*** the supra-œsophageal ganglia are situated with their anterior margin on a line immediately posterior to the eyes. The combined width of the ganglia is about one-half that of the head. Each ganglion gives off laterally and in a forward direction, an optic nerve which branches to supply each of the simple eyes of the visual area. In front of the junction of the two ganglia is the frontal ganglion, small and shield shaped, connected to the supra-œsophageal ganglia by a pair of arms. Proceeding from each arm of the frontal ganglion, close to its attachment with the supra-œsophageal ganglion, is a nerve which extends forward and sends an outer branch to the labrum, and an inner branch to the dorsal region of the buccal cavity, see Plate XIV, Figs. 4 and 5, at lb_1 and b. Between the point of attachment of the arm of the frontal ganglion with the supra-œsophageal ganglion, and the optic lobe, (opt), is the slender antennal nerve rising from the anterior margin of the ganglion and possessing a fellow in like position upon the other ganglion, see Plate XIV, Figs. 4 and 5 at ant. Upon its posterior face, each ganglion gives rise to a protuberance from which issues a nerve that converges toward its fellow and meets it upon a median line. At this union a small ganglion is formed and to this are also joined, the nerves coming from the sympathetic ganglia. These sympathetic ganglia are single, one upon each side of the œsophagus and possessing a nerve connection with the posterior protuberance of the supra-œsophageal ganglion of its respective side, See Plate XIV, Figs. 4 and 5.

The recurrent nerve of the frontal ganglion extends in a posterior direction between the supra-œsophageal ganglia and the œsophagus

* A contribution from the Department of Entomology, Cornell University, prepared under the supervision of Dr. O. A. Johannsen, to whom and also to Dr. J. G. Needham and Dr. J. T. Lloyd, I wish to express my gratitude for the valuable assistance rendered.

† In gross dissection, hot water killing and Gilson's fixing solution were found to be most advantageous.

and fuses with the nerve which extends posteriorly from the ganglion situated at union of the nerves from the posterior protuberances of the supra-œsophageal ganglia and the sympathetic ganglia of each side.

From the ventral face of the supra-œsophageal ganglia, arises a pair of connectives, the crura cerebri, which connect the supra-œsophageal ganglia with the sub-œsophageal ganglion.

Immediately in front of the union of the crura cerebri with the supra-œsophageal ganglia, the œsophageal ring of the tritocerebrum arises. This is a loop which encircles the œsophagus and has its ends connected with the supra-œsophageal ganglia, see Plate XIV, Fig. 5 at or. The supra-œsophageal ganglia does not fit closely upon the œsophagus normally, but leaves some space laterally and ventrally for the expansion of the tube in feeding. Faivre 1857, states that the supra-œsophageal ganglia possess the seat of motive power and will power and Binet, 1894, strengthens this statement by the results of his own experiments which show that an insect will live for months with the supra-œsophageal ganglia removed but will not eat unless the food is placed in its mouth as it has no power to move toward the food.

The sub-œsophageal ganglion is situated slightly back of the posterior margin of the supra-œsophageal and below the œsophagus but well within the limits of the head cavity. This ganglion gives off three pairs of nerves, the most ectal and dorsal of which extends in a forward and upward direction and, upon a level with and in front of the frontal ganglion, branches. One branch extends to the base of the labrum, see Plate XIV, Figs. 5 and 6 at lb2, while a second branch extends to the dorsal side of the mandible, see Plate XIV, Figs. 5 and 6 at md2. The second pair of nerves from the sub-œsophageal ganglion arises ventrad of the first pair and extends forward also branching. The ectal branch of each nerve reaches the musculature of the maxilla, mx1; and an ental branch divides and one part goes to the maxillary sclerite and the other to the labium, see Plate XIV, Figs. 5 and 6, at mx2 and li2. This pair is connected by a nerve just below the frontal ganglion, and the cross nerve bears a small median ganglion. The third pair of nerves is ventrad of the second pair and extends forward directly to the labium, which it innervates, li1.

The above description is made from several dozen specimens of the species *Limnophilus indivisus* Walker. The head ganglia of the other species studied do not vary materially.

Posteriorly the sub-œsophageal ganglion gives off a pair of commissures which connect to the first thoracic* ganglion lying in the prothorax. In the thorax and abdomen there is much variation among the species as to the relation of the ganglia to their respective segments. Upon observation of these three species (*Limnophilus indivisus* Walker, *Hydropsychodes analis* Banks and *Phryganea interrupta* Say,) two centers of fusion will be found, one in the thorax and one in the abdomen at the posterior end of the chain. As above stated, there are three thoracic and eight abdominal ganglia. The prothoracic and

* Each ganglion of the thorax and abdomen is a pair of fused ganglia.

mesothoracic ganglia are about the same size as the sub-œsophageal ganglion and are each situated equidistantly from the anterior and posterior margins of the segments and this condition prevails for the three species. The metathoracic ganglion is larger than those of the preceding segments and its position is not the same in the different species for it is here that the thoracic fusion point occurs. In *Phryganea interrupta* the ganglion is centrally located with the ganglion of the first abdominal segment just within the posterior border of the metathorax. In *Limnophilus indivisus*, the metathoracic ganglion has migrated forward and the first abdominal ganglion has followed until the latter occupies the central position with the metathoracic ganglion well in the front half of the segment. In *Hydropsychodes analis*, the condition is the same as in *L. indivisus*.

In the abdomen of the three species the positions of the ganglia are more noticeably variable. In *P. interrupta* the first abdominal segment bears at its posterior margin, the ganglion of segment two and segment two is void of any ganglion, but receiving its innervation from its respective ganglion located in segment one. The ganglia of segments three, four, five and six occur in their respective segments near the front margins. Segment seven bears in its front half, two ganglia; these are the ganglia for segments seven and eight and they are very closely united, but not fused at all, Plate XIV, Fig. 2. In *L. indivisus*, the ganglion of segment two occupies a central position in segment one, indicating a forward migration. Segments three, four and five have their ganglia in the front half of the segment as in *P. interrupta*. In segment six all the ganglia of the three segments, six, seven and eight, are placed; those relating to segments seven and eight are closely united, practically fused, and take a position in the posterior half of the segment. The ganglion for segment six is in the anterior half of the segment, Plate XIV, Fig. 1. In *H. analis* we find an arrangement in the abdomen which varies from that which Pictet, 1834, observed in Hydropsyche, for he saw all the ganglia here upon the divisions between the segments. In this particular species, the ganglion for segment two is in segment one as usual, and the ganglion for segment three is on the margin between segments two and three which is a forward migration. The ganglion for segment four is in front of the center of the segment and the ganglion for segment five is back of the center of its respective segment. In the sixth abdominal segment are three ganglia, for segments six, seven and eight respectively and all are in a line and practically fused, Plate XIV, Fig. 3.

The thoracic ganglia and the abdominal from one to six innervate their respective segments and appendages, the seventh abdominal appears to have only one pair of nerves which extend backward into segment seven, the eighth abdominal ganglion innervates segment eight and nine, as well as the swimmerets, which extend out from segment nine. There are various ways for the eighth abdominal segment to innervate segment nine. In *P. interrupta* and *H. analis* it sends a nerve directly to the segment, but in *L. indivisus* the nerve which extends to segment eight branches and sends a branch to segment

nine, this arrangement leaves one less pair of nerves arising from ganglion eight in *L. indivisus* than in *P. interrupta* or *H. analis*.

Upon a comparison of the three Figures, Nos. 1, 2 and 3, Plate XIV, a sequence of fusion is evident. This sequence places *P. interrupta* as the most generalized and *H. analis* as the most specialized and *L. indivisus* as intermediate. Vorhies, 1905, has described the nervous system of *Platyphylax designatus* Walker and it falls between *P. interrupta* and *L. indivisus* for the ganglia of the seventh and eighth segments have migrated so that the ganglion for segment seven is just inside the posterior margin of segment six and the ganglion for segment eight remains in segment seven, but very close to its anterior margin. Betten, 1901, in his description of *Molanna cinerea* does not show it to vary from *P. designatus*. Pictet, 1834, figures *Phryganea striata* Fab. to fall between *P. designatus* and *L. indivisus* with the ganglia for segments six, seven and eight in segment six, but ganglia seven and eight not fused. Klapalek, 1888, does not note any variation of position, but merely gives the number of ganglia and their general distribution.

From the above it seems reasonable to think that the nervous system of the order will reveal grades of consolidation of the ganglia which may have a decided bearing upon classification.

REPRODUCTIVE SYSTEM.

The writer has done very little in this system beyond the mere location of the organs, for the matter seems to have been given adequate attention by Zander, 1901, Lubben, 1907, and Marshall, 1907. As to the period of the appearance of the organs there is a difference of opinion. Pictet, 1834, Klapalek, 1888, and Vorhies, 1905, make the statement that the organs do not appear until near the period of pupation or at least in a very old larva; Lubben, 1907, discusses conditions in a transforming larva, while Marshall, 1907, speaks of the condition of the organs in the youngest larva he had, but does not give the stage. In all the specimens observed by the writer, the gonads appear in the early forms, showing clearly both in gross dissection and sections. In *P. interrupta* taken in October and *H. analis* taken in late December from under the ice in streams, the gonads are distinct and developed far enough so that tubules may be seen, Plate XIV, Fig. 7. This period is long before there are any signs of pupation either in case or larva.

Within the species two shapes of gonads appear. In *P. interrupta* some are elongate and flat, while others are spherical. This seems to point to a sex differentiation, the elongate one probably destined to become female organs and the spherical ones male organs, Plate XIV, Fig. 2. In gross dissection in *L. indivisus* only one kind of a gonad was observed, this circular and plate-like of five pairs of tubules. Plate XIV, Fig. 1, at gd. In each gonad there are two outgrowths or attachments; one from the outer side and extending to the ventral body wall of the second abdominal segment and resembling a supporting thread or tissue, the inner side outgrowth appears as a duct and the tubules of the gonad may be seen converging toward the head of this duct.

The duct extends in a posterior direction and extends to the ventral side of the eighth segment, where it is lost. Lubben, 1907, shows that these ducts pass into external, sculptured plates in the eighth segment but I have been unable to find any such structure or any opening whatever at this point on any of the specimens. In *H. analis* the gonad is oval, but appears spherical in frontal section as the long axis of the gonad is at right angles to that of the body of the larva. The gonads of the above three species are in pairs and lie in the fifth segment of the abdomen Betten, 1901 finds the gonads for *M. cinerea* in segment four; Lubben, 1907, records *Anabolia nervosa* and *Limnophilus stigma* as having the organs in segment five, *Rhyacophila septentrionis* and *Brachycentrus montanus* in segment four. Klapalek, 1888, gives the gonads a general location of segment three, but neither literature nor my own observations uphold this statement. From a compilation of records the position appears to be in either the fourth or fifth segment.

ALIMENTARY CANAL.

General description: The alimentary canal, in the order Trichoptera, passes as almost a straight tube from buccal cavity to anus. Pictet, 1834, figures the tube as practically undifferentiated in its shape and only varying slightly in size at the extreme ends. Klapalek, 1888, states that the regions merge imperceptibly into each other. Although this condition may be true in a specimen gorged with food, the writer has never seen a specimen where the three main divisions of stomodeum, mesenteron and proctodeum were not distinctly marked one from the other. The lack of convolutions as are normal in the alimentary canals of insects which are herbivorous, is unusual, as Siltala, 1907, shows that the order is in the main herbivorous and yet this general type of a straight tube prevails. There are a few semi-carnivorous species, but even here there is no variation from the above condition. The assimilative area is increased by an unusual width in proportion to that of the body, for in many places and especially the mesenteron, the width is equal to one-third and frequently more than one-third the width of the abdomen. Another device adds to this area or surface for the wall of the mesenteron is folded into transverse ridges which increase the surface by three times that actually occupied by the wall, Plate XV, Fig. 10. These folds are deeper in the strictly herbivorous types, such as *L. indivisus*, than in those which are more or less carnivorous, as *H. analis*. We will pass now to a discussion of the alimentary canal in the three species. *Hydropsychodes analis* Banks, Plate XV, Figs. 7, 8 and 9. The surface of the stomodeum of the alimentary canal presents a silvery appearance, due to the peritoneal covering of the muscles which surround and control the activities of this portion of the canal. This portion is much darker than the remainder of the canal, due to the food within. If this be cleaned, the wall appears transparent. Beneath the peritoneal membrane can be seen the longitudinal muscles arranged in pairs in six equi-distant places around the canal. Underneath these longitudinal muscles lie the circular muscles, which are so

heavy and thick that they give the canal the appearance of having great rings around it. The stomodeum is composed of four parts, namely: buccal cavity, œsophagus, crop and proventriculus. The buccal cavity is large, including half the depth of the head capsule, it narrows rapidly and passes over into a slender tube which passes beneath the supra-œsophageal ganglia as the œsophagus. The œsophagus extends backward through the head and prothorax with only slight expansion. At the posterior margin of the prothorax it begins to enlarge and extends through the length of the mesothorax with a diameter one-third that of the thorax and four times the diameter of the œsophagus in the prothorax. This is the crop. At the posterior margin of the mesothorax the stomodeum is suddenly constricted to about half its width and within a longitudinal distance of .5 mm. suddenly enlarges to form a cylindrical structure, the wall of which becomes resistant to dissecting instruments and is very hard. The circular muscles are larger and heavier in this region and inside the tube are chitinized teeth. This portion is the proventriculus, which functions as a grinding organ and possibly as a straining device.

The cylindrical shape ends suddenly at the posterior margin of the metathorax and the transition into the mesenteron is well indicated by change in color, texture and structure of the wall and by a deep fold. The proventriculus pushes into the forward end of the mesenteron and forms there an œsophageal valve. The mesenteron folds up over the proventriculus and causes a distinct line to appear between the two portions. The silvery tone of the wall is lost at this juncture; the longitudinal muscles break up to form a layer of muscles around the mesenteron and this layer extends the full length of the mesenteron. Beneath these muscles can be seen the very thin layer of circular muscles. The mesenteron enlarges at its beginning to at least a third the diameter of the abdomen of the larva and increases slightly toward the fourth segment and then returns to its width at the beginning before it reaches its length. This division arises at the posterior end of the metathorax and extends through the length of the abdomen as an almost straight tube, varying only as above in diameter, circular in cross section, and possessed of an extremely thick wall, but one that is easily torn apart. In the sixth segment the mesenteron becomes about two-thirds the diameter at its beginning and passes over into the proctodeum. The proctodeum is composed of intestine, both large and small, and the rectum. The mesenteron pushes into the intestine in much the same manner that the proventriculus pushes into the mesenteron, but the distance is not as great and the valve formed is not a distinct one in this species, although the division between the two main divisions of the canal is clearly marked. At the point where these two portions meet, the Malpighian tubules, of which there are six, make their appearance upon the surface. These tubules are situated upon the lateral and ventral faces of the alimentary canal and the dorsal face is void of them; however, the first pair may be easily seen from a dorsal view, each member of this pair lies upon the upper portion of the lateral face and extends forward through the abdomen and into the metathorax. Slightly

below the first pair, the second pair arises and extends, each member of the pair upon its respective side of the alimentary canal, forward for the remaining distance of the sixth segment where it turns backward and taking an upward and lateral direction, with regard to the intestine, curves and coils about in the lower part of the abdomen back of the sixth segment. The third pair of tubules is situated upon the venter about equidistant from each other and from the corresponding members of the second pair. This third pair extends backward immediately and each member comes to lie beneath and to the side of the intestine, intertwining with the corresponding member of the second pair. The tubules are irregular in outline, appearing like small oval beads strung upon a thread. In general color they are a pale, clear yellow, but blotched at irregular intervals with a kidney-brown pigment. They weave in and out among the fat bodies and tracheæ, and into blood sinuses to perform their function of the removal of nitrogenous waste.

The front end of the intestine is cup-shaped with the larger end forward. This portion represents the small intestine. The tube grows smaller as it proceeds toward the caudal end, but in the seventh segment is greatly constricted; it enlarges immediately and passes through segment eight with a diameter of about a fourth that of the segment and two-fifths of the diameter of the mesenteron in the first segment. This portion represents the large intestine.

At the posterior margin of segment eight, the intestine is again constricted and passes over into the rectum. At this juncture there is a semi-valve formed by the invaginated walls of the intestine. These folds become longer and fewer in number and form the blood gills which lie in the rectum. The rectum extends through the ninth segment. In some forms examined, the small diameter of the constricted region at the posterior end of segment seven prevails through the eighth, widening suddenly at the beginning of the ninth to accommodate the invaginations forming the blood gills; in other forms the widening is gradual through the eighth and passes over gradually into the rectum without any noticeable constriction. The wall of the small intestine is heavy and surrounded with circular muscles. It becomes thinner as it extends toward the large intestine. When the rectum is reached the wall is exceedingly thin and almost transparent. Through the wall can be seen the four pockets or invaginations which form the blood gills, and into these muscles extend from the lateral and ventral walls at the conjunctiva between segments eight and nine. The rectum now serves a double function, that of elimination of fecal matter and secondarily that of respiration, when oxygen cannot be obtained by means of the tracheal gills. These blood gills have no tracheæ running into them as a glycerine mount of the caudal portion of a fresh specimen clearly demonstrates. They function, when the larva is out of the water, by protruding themselves through the T-shaped anus, in which state they are filled with blood. A detailed account of their structure will be found elsewhere in this paper.

Limnophilus indivisus Walker,* Plate XV, Figs. 1, 2, 3 and 5. In this form the œsophagus passes from the buccal cavity into the head region where it is a small tube and continues through the prothorax. The crop is absent in this form and the œsophagus passes immediately into the proventriculus. Here the chitinized "teeth" upon the lining such as we find in *H. analis* are lacking. They are not needed, as the form is strictly herbivorous and *H. analis* is semi-carnivorous. The œsophagus begins to enlarge at the posterior edge of the prothorax to form the proventriculus, which lies in the mesothorax. It is silvery in appearance and dark colored, but not resistant to the needle owing to the lack of chitinized teeth within. The proventriculus possesses the six pairs of longitudinal muscles and the circular layer, but these are not as heavy as in *H. analis*. At the posterior margin of the mesothorax the proventriculus constricts slightly and passes over into the mesenteron. This position is contrary to the usual division level for these two portions of the alimentary canal, but the œsophageal valve occurs here and the character of the wall changes to a light pale color, is thicker in cell depth and the six pairs of muscles from the proventriculus form the characteristic layer around the new division. From these characteristic markings there can be no doubt as to this transition. The œsophageal valve is normal, Plate XV, Figs. 2 and 3 show it as a complete invagination of the wall, in a fold of eight projections

The mesenteron takes its beginning in the mesothorax and increases in diameter as it passes through the metathorax. It may be slightly constricted in the first abdominal segment although it frequently passes without any change of contour. It passes through the abdomen at its diameter of one-third that of the abdomen and extends to the sixth segment. Here the transition into the intestine occurs and the juncture is marked by the presence of the six Malpighian tubules, in the same arrangement as in *H. analis*. The tubes are longer, however, and the first pair does not extend into the thorax, but turns backward in the first abdominal segment and returns to the seventh. The second pair frequently extends as far as segment three and then returns to segment eight. The third pair may continue forward through segment six before turning backward. The junction between mesenteron and intestine is marked by a decided valve not found in *H. analis* and similar to the œsophageal valve. A section showing this structure is on Plate XV, Fig. 10. The intestine at its forward end is also cup-shaped and, at the constriction between small and large intestine, possesses a valve formed by the invagination of the intestinal wall. (Plate XV, Fig. 5). Along the intestine are six muscle bundles which seem to control the initial position of the Malpighian tubules. Marchal, 1892, considers the tubules as being capable of motion and perhaps these muscles have some part in that action. These muscles likewise support the front edge of the rectum into which the large intestine telescopes.

* This species is selected for a comparison with *H. analis*, as the two represent widely divergent forms.

Phryganea interrupta Say* Plate XV, Fig. 11.

In *P. interrupta*, the œsophagus passes through the head as a narrow tube and enlarges toward the posterior margin of the prothorax to form a crop of small dimension which is marked from the proventriculus by a slight constriction. The proventriculus occupies the meso and metathorax in length and practically fills the whole of the body cavity in this region, it presents the silvery surface as in the other forms and the longitudinal and circular muscles are evident. The posterior end of the proventriculus extends over into the first abdominal segment and here is constricted suddenly and passes through this segment as a small tube about one-fourth the diameter of the proventriculus in the mesothorax. This constriction is so long that the longitudinal muscles of the proventriculus do not follow the tube but span the distance from the beginning of the constriction to the surface of the mesenteron and can be seen as threads across the open space.†

The mesenteron is the same as in the other forms and passes over into the intestine of the proctodeum in the sixth segment where the Malpighian tubules arise. These do not always assume the same positions, which is further evidence of Marchal's theory on their mobility. Marchal, 1892. The intestine extends through segments six and seven and at the anterior margin of the eighth there is a constriction as the intestine passes over into the rectum. The rectum gradually grows smaller as it nears the anus. The anterior portion of the intestine has a heavy musculature and the lower part is ridged longitudinally and these ridges become more prominent in the rectum and form four longitudinal columns which continue to the anus.

HISTOLOGY OF THE ALIMENTARY CANAL.‡

In this work the writer has divided the material into two parts: that dealing with cellular structure and that relating to the musculature of the canal. The condition in *H. analis* is taken as a basis of comparison and where *L. indivisus* differs from the above the condition is noted and illustrated in the figures.

Buccal cavity: The cells are flat and small with small nuclei The cavity is heavily lined with chitin.

* This third species is selected on account of its larger size.

† A normal œsophageal valve occurs at the division between proventriculus and mesenteron.

‡ In the histological work, both hot Gilson's and hot Bouin's were used with equal advantage if the material was to be used at once. If more than a month were to elapse before the material would be used, Bouin's was by far the better fixative, as those in Gilson's softened rapidly.

Much better results were attained by clearing in xylol than in cedar oil. An infiltration of not longer than nine hours, including the time in xylol and paraffin, equal parts, at 52 degrees F., produced the material most easily cut.

Staining in Delafield's haemotoxylin and counterstaining in aqueous ½% eosin produced excellent results as a general stain. For muscles and epithelial cells, iron haemotoxylin made clearer slides than the above. Paracarmine with a counter stain of orange G. was especially adapted to digestive epithelial tissue in *L. indivisus*.

Oesophagus: The cells of the epithelium are cubical and the whole epithelium is lined with a chitinous intima. The basement membrane is distinct between the epithelium and the muscles surrounding the œsophagus.

Crop: Conditions the same as in the œsophagus.

Proventriculus: The cells of the epithelium do not vary from those of the œsophagus but the wall itself is thrown into folds and the intima becomes thick and dense and forms the stomachic teeth, the number of which is about thirty-six. A cross section of this region shows them surrounding the cavity. At the posterior margin of the proventriculus is the œsophageal valve which in this form is of peculiar plan. It is practically double with a strongly chitinized invagination into the proventriculus and an extremely deep but narrow invagination into the mesenteron. This valve does not completely surround the constriction between the two divisions. For further details see Noyes 1915. This valve in *L. indivisus* is normal and complete. It extends into the mesenteron in a fold, the upper part of which is composed of cubical cells with an extremely heavy intima, while the under portion of the fold although the cells are cubical become somewhat flattened and the intima reduced to a thin membrane. The wall changes suddenly into the columnar structure of the mesenteron with its striated border. At the point where the intima ceases the peritrophic membrane arises. This is separated from the epithelial wall of the mesenteron and surrounds the food in the canal, Plate XV, Fig. 6.

Mesenteron: The epithelium here is similar to that at the posterior end of the œsophageal valve except that the cells become more columnar. The conditions in function accord with those described in the dragonfly nymph, Needham, 1907, and need no further discussion here. The wall of the mesenteron is folded as mentioned in the discussion of the gross anatomy of the canal to produce more assimilative surface and this condition prevails the entire length of the mesenteron to the sixth segment. In this same segment the Malpighian tubules show upon the surface and the mesenteron passes over into the intestine, Plate XV, Fig. 10 at dep.

Malpighian tubules: At the posterior end of the mesenteron where the cells are still columnar, the ventral pair of Malpighian tubules may be seen breaking through the epithelial wall on their way to the surface, Plate XVI, Fig. 7. Patten, 1884, in his embryological investigation of the Trichoptera shows that these tubules are evaginations of the proctodeum before the wall of the forming mesenteron is joined with that of the proctodeum. Further evidence of this is seen in sections of the intestine further back where the tubules may be seen forming within the epithelial tissue of the intestinal walls. The cells are still columnar but the presence of intima and the loss of the striated border indicate that this is no longer mesenteron, Plate XVI, Fig. 6. The Malpighian tubules are composed of large cells, glandular in appearance, with a large nucleus in the center of the cell. The pigment so noticeable in gross structure now becomes more evident and stains darker than the nucleus and is not confined to a given region of the cell. There are three

distinct layers; upon the inside is the lining or the intima, then the large celled wall and the covering which is muscular, Plate XVIII, Figs. 7 and 8. The dorso-lateral and lateral tubules reach the surface posterior to the ventral pair.

Intestine: The transition to intestine in *H. analis* is accomplished with a mere constriction and change in cellular structure, but in *L. indivisus* there is a valve formed as the œsophageal valve is formed, but reversed in its components, the upper part of the fold is slightly columnar in its cellular structure but covered with intima in a thin coat, the intima becomes thicker and the cells cubical as the folds turn toward the intestinal wall, Plate XV, Fig. 10. At the posterior edge of segment seven the cubical wall changes and becomes large celled with large nuclei, Plate XVI, Fig. 2. In *H. analis* this continues to the anterior margin of the ninth segment, Plate XVI, Fig. A at 2. At the beginning of the ninth segment the epithelial wall changes to a cubical condition which changes only as the wall becomes differentiated into the blood gills and returns to the cubical condition when this function ceases. The whole length of the intestine is thrown into six longitudinal folds which begin in the sixth segment, Plate XVI, Fig. 6, and is traceable through all the sections to the rectum where the semi-valve occurs and the four blood gills arise. The folds do not continue into the rectum. In *L. indivisus* transition in the eighth segment from the cubical celled condition to the large celled, which marks the end of the intestine in this form, is a distinct rectal valve not different in character or formation from the one into the intestine from the mesenteron; the cells of the wall of the rectum are large with large nuclei and this condition continues to within .5 mm. of the anus. It is possible to consider the rectum of *H. analis* as beginning at this level and the semi-valve as only the transition into the blood gills, but the gross anatomical structure seems to bear the former interpretation.

Musculature: The œsophagus is surrounded with bundles of longitudinal muscles, outside of which is a layer of banded circular muscles and outside of these six pairs of longitudinal muscles so noticeable in gross structure. At the anterior end of the proventriculus the inside layer of longitudinal muscles cease and the proventriculus is immediately surrounded by circular muscles, (see Noyes 1915), which continue as a sheath of varying thickness for the full length of the alimentary canal as far as the rectum.

Mesenteron: The six pairs of longitudinal muscles break up into a layer of longitudinal muscles, this layer is composed of large bundles upon the outside and small ones upon the inside next to the thin circular muscles. See Plate XVI, Fig. 7.

Intestine: At the anterior end of this division where the cells of the epithelium are columnar but covered with intima, a heavy circular muscle arises pushing some of the longitudinal muscles outside and enclosing the smaller ones, Plate XVI, Fig. 6. In a very few sections of .008 mm. in thickness this muscular wall is complete, Plate XVI, Fig. 5. The inner layer of circular muscles becomes thicker as we advance toward the posterior end of the canal and the inner longitudinal

muscles have formed themselves into the characteristic six pairs and those pushed to the outside of the outer circular muscles have ceased, Plate XVI, Fig. 4. This heavy outer circular muscle comes to an end in the seventh segment, leaving the six longitudinal pairs as the exterior layer, Plate XVI, Fig. 3. This condition prevails throughout segment eight, Plate XVI, Fig. 2, and past the semi-valve into the gill chamber of the rectum, Plate XVI, Fig. 1. For a diagram of this musculature, see Plate XVI, Fig. A, the levels drawn are numbered as the figures which are taken in cross section at these same levels. The musculature of *L. indivisus* does not vary from this description based upon *H. analis*, with the exception that in the mesenteron the longitudinal muscles are of a single layer, Plate XVI, Fig. 8. The blood gills of *H. analis* rightfully belong to the discussion of the histology of the alimentary canal, but their structure is sufficient to claim for them a separate division of this paper.

Blood Gills of *Hydropsychodes analis* Banks.

Protruding from the T-shaped anus, Plate XV, Figs. 8 and 9, Plate XVII, Fig. 1, are often seen four transparent, greenish, finger-like appendages, Plate XIV, Fig. 3. These are protruded beyond the limits of the anus when the larva is out of the water crawling upon the rocks, or may be artificially protruded by pressure upon the abdomen in the caudal region. Pictet, 1834, states that these appendages contain tracheæ. There are muscles leading into the gills which might be mistaken for tracheæ if the microscope were not of high magnification. Dufour, 1847, figures these gills as appendages from the rectum into the body cavity, but without tracheæ. This error of Dufour is easily understood when the larva is dissected, for it is almost, if not quite, impossible to open a larva from the dorsal side and not cut into the rectum so that these gills float out as though appendages from it. It is only when a lateral opening is made that the true internal position is observed. Fritz Muller, 1888, does not show any tracheæ in the gills and Thienman, 1903, and Lubben, 1907, represent these as non-tracheæ bearing structures. In the glycerine mounts of the caudal end of the abdomen with the gills protruding from the anus, the tracheal tubes are seen to pass down the sides of the body sending branches to the alimentary canal and surrounding tissues. Long branches or continuations of the main tracheal trunks extend into the anal pro-legs or drag hooks, but in no instance does a single tracheole extend to a gill. In neither the transverse sections or the longitudinal ones does tracheal structure appear. Muscles and blood make up the content of the gill. These gills are in direct communication with the body cavity and it is possible that, when occasion renders the supply of oxygen insufficient, the blood rushes from the blood sinuses into these "pockets" and comes with sufficient force and quantity to extend the gill and push it to the exterior and an exchange of gases takes place through the wall of the gill. This action, combined with the lack of tracheæ, seems sufficient evidence upon which to claim the term of ***true blood gills*** for these structures.

When retracted these gills lie within the rectum, which serves a double function, with their distal ends or tips close to the anus and just barely within the aperture. They may function slightly at this time.

In surface view the gills present a cylindrical form which tapers as it extends distally. Upon the surface are transverse ridges which are bounded by thread-like depressions. These depressions are as deep as the ridges are wide, for these ridges are made up of rings of cells one cell deep and one cell wide. At rest these cells are cubical, being as deep as they are wide, and the depressions are the expansion spaces between the cells. In expansion this ring of cells becomes narrower in diameter and the cells themselves wider and more shallow. Compare Plate XVII, Fig. 6, where the gill is at rest, and Fig. 7, where it is in extended condition. The tips of the gills are more dense and of a darker color than the rest of the gill. This condition is due, no doubt, to their close proximity to the anal aperture and to the fact that they must at times push their way through waste material in their extension.

To get a clear conception of the formation of these gills, it is necessary to start with their origin in the wall of the intestine in the ninth segment. Here the glandular large celled condition of the intestinal wall ceases and becomes cubical. The wall is thin and the six longitudinal folds extend inward so as to form a semi-valve at the head of the rectum, Plate XVII, Fig. 4. Gradually these folds merge into four and form the four gills. Plate XVII, Fig. 5, shows these longitudinal folds merging into the gills and being continuous with them. After the formation of the gill the rectal wall does not again fold, but passes directly to the anus.

At rest the width of the gill is about one-third its length, which normally is slightly less than the width of the ninth segment. The gill is capable of extension to about three times its normal length, and at this time the wall becomes thin and the cells much longer than deep. Not all of this extension length is made by the gill itself, as the folds at the head of the rectum extend and the caudal wall of the rectum itself is carried down with the gills, Plate XVII, Fig. 7.

The deep cells of the walls of the gills are possessed of large nuclei and are glandular in appearance. These cells take up about four-fifths of the diameter of the gill when at rest, leaving the other fifth for the muscle which extends from the conjunctiva of the lateral and ventral walls between segments eight and nine. Each gill possesses a muscle which arises at a corresponding place upon the conjunctiva and extends to the tip of the gill. Each gill muscle is three branched, Plate XVII, Fig. 8, and when at rest lines the gill. The gills are covered with a very thin intima, which is continuous with that of the rectum and intestine.

GLANDS.

Not all the glands in the body of the trichopterous larvæ are considered here. The writer has confined her attention to the silk glands, the thoracic glands and the glands in the head, in this last only those in *L. indivisus* have been studied.

The Silk Glands: Of all the glands of the trichopterous larvæ these are the most prominent. They practically fill the part of the body cavity not occupied by the alimentary canal and extend from the labial spinneret into the seventh segment. They are opaquely white, having a pinkish cast in a fresh specimen. Their content is sticky and if the glands of a fresh specimen be broken in dissection the secretion will so glue the organs and tissues together as to make further dissection impossible. This difficulty is remedied by applying Gilson's preservative to the freshly opened specimen and allowing it to remain for fifteen or twenty minutes.

Upon the floor and in the center of the anterior edge of the labium is a spinneret, Plate XVIII, Fig. 3, at sp. This is connected to a single tube of .2 mm. in length. In this region is the silk press composed of muscles which control the flow of secretion. This structure does not differ from the structure of the forms studied by Gilson, 1894, and needs no further discussion in this paper. At the posterior margin of the labium this single, slender tube becomes divided into two and passes ventrad of the nerves extending from the sub-œsophageal ganglion to the mouth parts. On reaching the ganglion each member of the pair of tubes passes laterad of the ganglion, Plate XVIII, Fig. 4, and then approaches its mate and passes with it underneath the œsophagus. At the posterior margin of the sub-œsophageal ganglion the tubes change their character from that of a duct to a true gland. In the duct the cells are small with simple nuclei. Externally the change is marked with a depression as though a thread were fastened tightly around the tube. Back of this depression is the gland proper, composed of an outer wall with an irregularly shaped nucleus in a flattened cell. This outer wall is two cells in circumference, the cells are hexagonal with the lateral face in a triangle. The front face of the triangle meets the posterior face of the triangular side of the other cell, see Plate XVIII, Fig. 5. Inside of this wall, which is frequently very loosely applied, is the inner tube consisting of a firm cylindrical wall, where the secretion is formed and inside of this heavy wall is a narrow tube through which the secretion passes to the duct, Plate XVIII, Figs. 6 and 6a.

These silk glands lie ventrad of the alimentary canal throughout the thorax and frequently as far as the second abdominal segment. Finally they make their appearance at the sides of the alimentary canal and increase in size. They extend to the sixth segment where they turn forward again and extend to the second and third abdominal segment, turning backward they reach to the seventh segment where the distal ends are frequently folded under the intestine or float free among the various folds of the Malpighian tubules, Plate XV, Fig. 1. For a detailed description of these glands see Vorhies, 1908.

Thoracic glands: Gilson, 1896, shows *Phryganea grandis* as possessing three glands or pairs of glands in the thorax, one pair to each of the segments. These glands are formed of small tubes which come together to form a small reservoir from which a single tube extends. This tube meets its fellow and together as one tube they open to the exterior in a small pore. Henseval, 1895–6, did not find the three pairs in all of the

forms studied but found a compound gland in the prothorax. This is the condition of *L. indivisus* and *P. interrupta*, although the structure of the two glands is not the same. In *P. interrupta* it resembles the glands found by Gilson in *P. grandis* and is much branched, Plate XVIII, Fig. 9, and Plate XIV, Fig. 2, ggl. The gland in *L. indivisus* is single and lies above the prothoracic ganglion, its opening is between the connectives of this ganglion to the sub-œsophageal and connects with a spinneret which lies at the extreme anterior margin of the prothorax and extends forward under the head, Plate XV, Fig. 1, at ggl, Plate XVIII, Fig. 1, ggl, and Fig. 10. In *H. analis* a gland, corresponding to this gland of Gilson, has not been found.

Glands in the Head of *Limnophilus indivisus* Walker.

In the head are six pairs of glands exclusive of the silk glands. Lucas, 1893, Henseval, 1895, and Russ, 1907, mention two pairs and term them mandibular and maxillary glands. *L. indivisus* possesses these two pairs and others. The mandibular gland is situated on the outer angle of the mandibular sclerite and is composed of a number of single celled glands or "pockets" which open into a common duct. This common duct leads to the base of the sclerite, the name of which it bears, Plate XVIII, Fig. 14. The maxillary gland, as Lucas so terms the second of the head glands, is similar to the mandibular but is composed of many more of the small single celled glands. The two glands lie underneath the œsophagus with their several small lobes folded upon each other and their ducts extending almost at right angles from each other. These ducts open into the buccal cavity at the inner margin of the mandibular sclerite, Plate XVIII, Fig. 13. Patten, 1884, states that they are an invagination of the inner margin of the mandibular sclerite in the embryo and Patten terms them salivary glands. Further ventrad in the lead lies a multicellular gland in the maxillary sclerite with an opening into the distal end of this sclerite, Plate XVII, Fig. 12. In the labium we find a pair of similar glands, Plate XVIII, Fig. 11. With these glands hitherto undescribed, and which we must, from their position at least, term maxillary and labial glands, the so-called maxillary glands of Lucas present a problem for nomenclature. Lucas ventures the theory that the glands of the head are coxal glands and the homologs of the parapodal glands of the annelid. If this theory be accepted then the maxillary sclerites may not be possessed of two pairs of glands nor may the mandibular sclerites. The writer prefers to use Patten's name of salivary gland, for the maxillary gland of Lucas.

Glands also exist at the base of the antennæ and below the visual area, but these are not figured.

Circulatory system of *L. indivisus:* This is simple as in all insects and consists of the dorsal vessel which extends from the ninth segment of the abdomen to the head, where it spreads out upon the supra-œsophageal ganglia. There are nine pairs of alary muscles beginning between the metathoracic and first abdominal segments and continuing to lie between the segments as far back as between the eighth and ninth. The first four are slender but the remaining five are heavy and connect with the one in front and behind it. In front of each pair of muscles, a valve exists in the dorsal vessel, Plate XIV, Fig. 8.

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EXPLANATION OF PLATES.

PLATE XIV.

Fig. 1. Central nervous system of *Limnophilus indivisus* and larval reproductive organs.

Fig. 2. Central nervous system of *Phryganea interrupta* and larval reproductive organs gd1=gonad from the ental lateral aspect. gd2=gonad frequently found and assumed to be the ovarian gonad.

Fig. 3. Central nervous system of *Hydropsychodes analis* and anal region with blood gills protruding from anus.

Fig. 4. Dorsal aspect of the supracesophageal ganglia of *Limnophilus indivisus*.

Fig. 5. Lateral aspect of the supracesophageal and subœsophageal ganglia of *Limnophilus indivisus*.

Fig. 6. Ventral aspect of subœsophageal ganglion of *Limnophilus indivisus*.

Fig. 7. Transverse section through the ovary of *H. analis*.

Fig. 8. Ventral aspect of the circulatory system of *L. indivisus*.

PLATE XV.

Fig. 1. Lateral aspect of the alimentary canal of *Limnophilus indivisus*.

Fig. 2. Oesophageal valve of *Limnophilus indivisus*. The portion of the canal containing the valve has been slit longitudinally and the valve laid open.

Fig. 3. A transverse cut back of the œsophageal valve.

Fig. 4. Diagram to show the relative position of the Malpighian tubules at the division between mesenteron and hind intestine.

Fig. 5. Transverse cut through the rectal valve at a level with 5 in Fig. 1.

Fig. 6. Lateral section through the œsophageal valve. The cephalic end of the valve is toward the bottom of the page.

Fig. 7. Lateral aspect of the alimentary canal of *Hydropsychodes analis*.

Fig. 8. Caudal aspect of anus of *Hydropsychodes analis*.

Fig. 9. Dorsal aspect of the anus of *Hydropsychodes analis*.

Fig. 10. Longitudinal section through the division point between mesenteron and hind intestine showing a valve, caudad of the Malpighian tubules; and the folded digestive epithelium of the mesenteron.

Fig. 11. Ventral aspect of the alimentary canal of *Phryganea interrupta*, only the ventral pair of tubules are figured.

PLATE XVI.

Fig. A. Diagram of the hind intestine of *Hydropsychodes analis*, with the levels at which the figures 1–6 are taken, indicated.

Fig. 1. Cross-section through the hind intestine at a point where a semi-rectal valve is formed by the invaginated folds of the intestinal wall.

Fig. 2. Cross section taken at level No. 2, showing the glandular structure of the large intestine.

Fig. 3. Cross section at level No. 3, showing the six folds of the small intestine with the cubical cell in the wall and the ental layer of circular muscles with the six pairs of longitudinal muscles.

Fig. 4. Cross section at level No. 4, showing the ectal row of circular muscles in addition to the condition in Fig. 3.

Fig. 5. Cross section at level No. 5, showing the beginning of the columnar epithelial cells and the breaking up of the six pairs of longitudinal muscles into a layer of smaller longitudinal muscles.

Fig. 6. Cross section at level No. 6, showing the Malpighian tubules forming in the hind intestine; also the breaking up of the ectal circular muscles. Note the presence of intima which indicates the structure as being a part of the hind intestine.

Fig. 7. A cross section slightly cephalad of the level of Fig. 6, showing the digestive epithelium in diagram and the heavy layer of longitudinal muscles characteristic of the mesenteron. The ventral pair of Malpighian tubules are seen here just coming to the surface.

Fig. 8. A portion of a cross section of the mesenteron of *Limnophilus indivisus*, which shows the normal two rows of muscles.

Plate XVII.

Blood Gills of *Hydropsychodes analis*.

Fig. 1. Cross section of anal region to show the T-shaped anus. × 70.

Fig. 2. Cross section through the anus with a gill lying in the aperture. × 70.

Fig. 3. Cross section through the rectum showing all four gills. × 70.

Fig. 4. Cross section through the "so-called rectal valve." × 140.

Fig. 5. Sagittal section of the gill region showing the intestinal wall invaginations that make the valve as at Fig. 4, and later make the gill wall itself and are continuous with the rectal wall caudad of the gills.

Fig. 6. Sagittal section of the gill region to show the retractile muscle of the gill and the relation to the body wall.

Fig. 7. Sagittal section of the gill region with the blood gills extended in function. × 125.

Fig. 8. Cross section of a functioning gill showing the three muscle branches.

Fig. 9. The blood which fills the gills when in function. × 320.

Plate XVIII.

Fig. 1. Dorsal view of the silk glands and Gilson's gland of *L. indivisus*.

Fig. 2. Ventral view of the mouth parts of *L. indivisus* with the silk glands located.

Fig. 3. Lateral aspect of the mouth parts of *L. indivisus*.

Fig. 4. Dorsal aspect of the silk glands in relation to the subœsophageal ganglion.

Fig. 5. Lateral aspect of a portion of the silk gland.

Fig. 6. Cross section of the gland proper of the silk gland of *H. analis*.

Fig. 6a. Cross section of the gland proper of the silk gland of *L. indivisus*.

Fig. 7. Longitudinal section of a Malpighian tubule.

Fig. 8. Cross section of a Malpighian tubule.

Fig. 9. Dorsal aspect of the Gilson's gland of *P. interrupta* in relation to the prothoracic ganglion.

Fig. 10. Dorsal aspect of the Gilson's gland of *L. indivisus* in relation to the prothoracic ganglion.

Fig. 11. Ventral aspect of the glands in the labial sclerite of *L. indivisus*. X 120.

Fig. 12. Ventral aspect of the gland in a maxillary sclerite of *L. indivisus*. X 120.

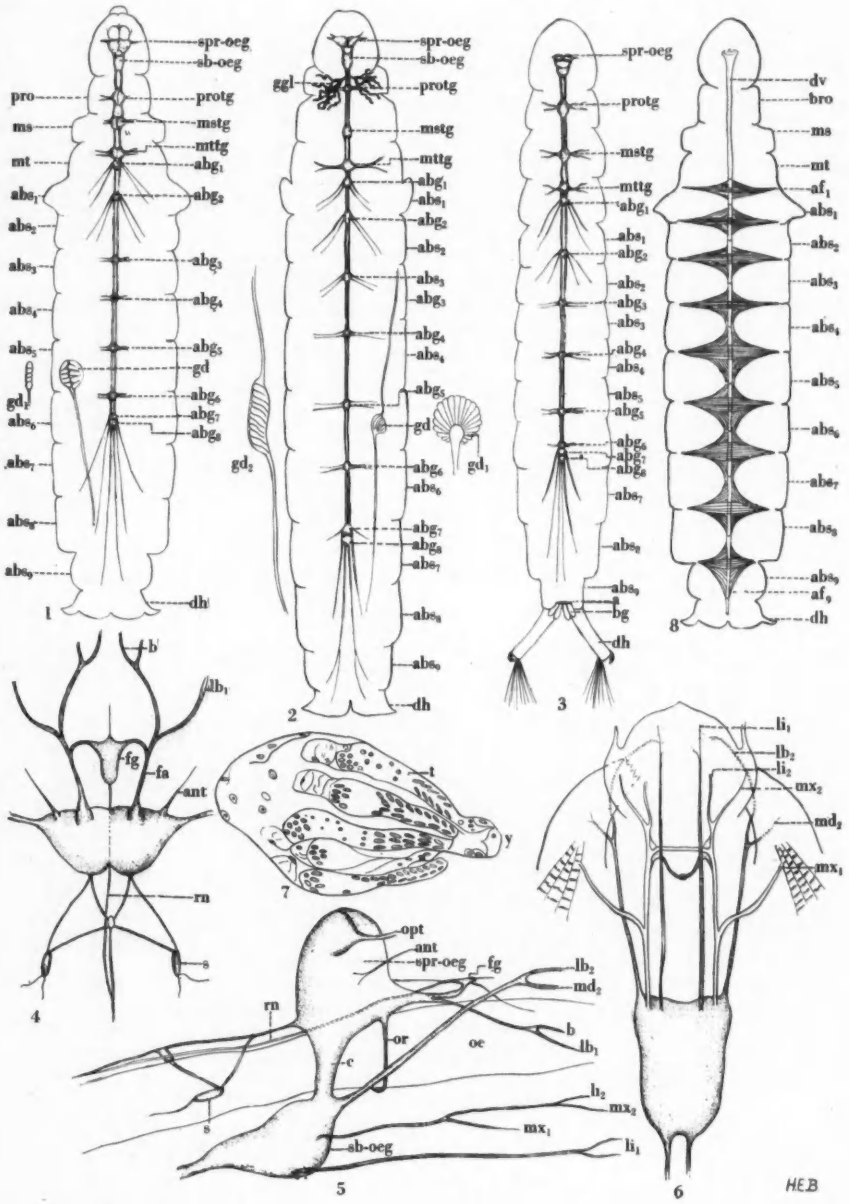
Fig. 13. Ventral aspect of the maxillary gland of Henseval and Lucas. × 30.

Fig. 14. Ventral aspect of the mandibular gland. × 30.

Fig. 15. Cross section of several of the unicellular portions of the maxillary gland of Henseval and Lucas. × 30.

INDEX TO FIGURES.

a = anus.
abg = abdominal ganglia 1 to 8.
abs = abdominal segment 1 to 9.
ant = antennal nerve.
af = alary muscle 1 to 9.
b = nerve to front of head.
bc = buccal cavity.
bg = blood gills.
bm = basement membrane.
c = crura cerebri.
cr = crop.
cm = circular muscles.
cp = corpuscle.
ct = conducting tubule.
dep = digestive epithelium.
dh = drag hooks.
dv = dorsal vessel.
ep = epithelium.
ex = expansion area.
excm = exterior circular muscle.
fa = frontal arm.
fg = frontal ganglion.
gd = gonad.
gd1 = gonad in inner aspect.
gd2 = probable ovary of *P. interrupta*.
ggl = Gilson's gland.
glep = glandular epithelium.
gsp = spinneret of Gilson's gland.
in = intima.
l = Lumen.
lb1 = labral nerve.
lb2 = labral nerve.
lb-s = labral sclerite.
li1 = labial nerve.
li2 = labial nerve.
li-s = labial sclerite.
l-int = large intestine.
lm = longitudinal muscle.
md2 = mandibular nerve.
md-s = mandibular sclerite.
me = mesenteron.
mp = Malpighian tubule.
mp1 = dorso-lateral pair.
mp2 = lateral pair.
mp3 = ventral pair.
ms = mesothorax.
mstg = mesothoracic ganglion.
mt = metathorax.
mttg = metathoracic ganglion.
n = nucleus.
oe = œsophagus.
og = opening of gland.
opt = optic nerve.
oev = œsophageal valve.
or = œsophageal ring.
p = pigment.
pm = gills press muscles.
pr = proventriculus.
pro = prothorax.
protg = prothoracic ganglion.
ptm = perotrophic membrane.
r = rectum.
rm = retractile muscle.
rn = recurrent nerve.
rv = rectal valve.
rw = rectal wall.
s = sympathetic ganglion.
sb-oeg = sub-oesophageal ganglion.
spr-oeg = supra-oesophageal ganglion.
skc = silk gland duct.
skp = silk gland proper.
sb = striated border.
sm-int = small intestine.
sp = spinneret.
t = tubule.
tr = trachea.
y = ventral end of ovary.



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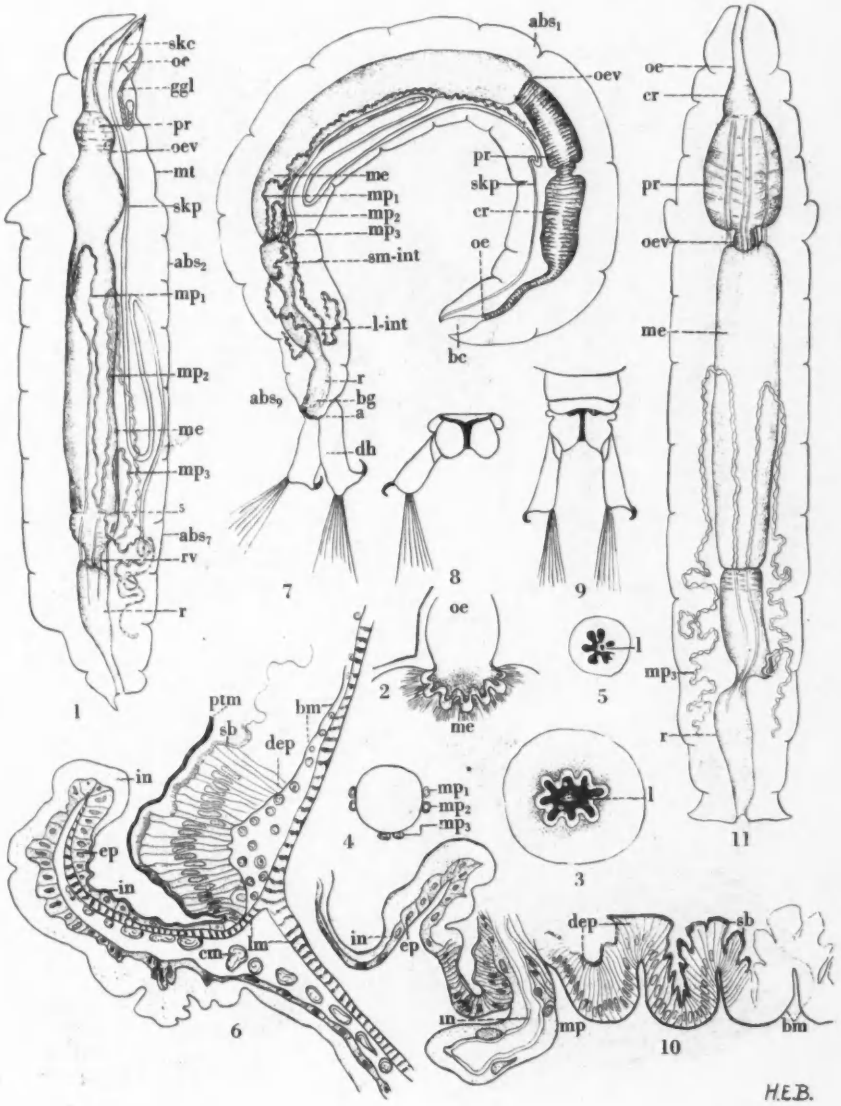

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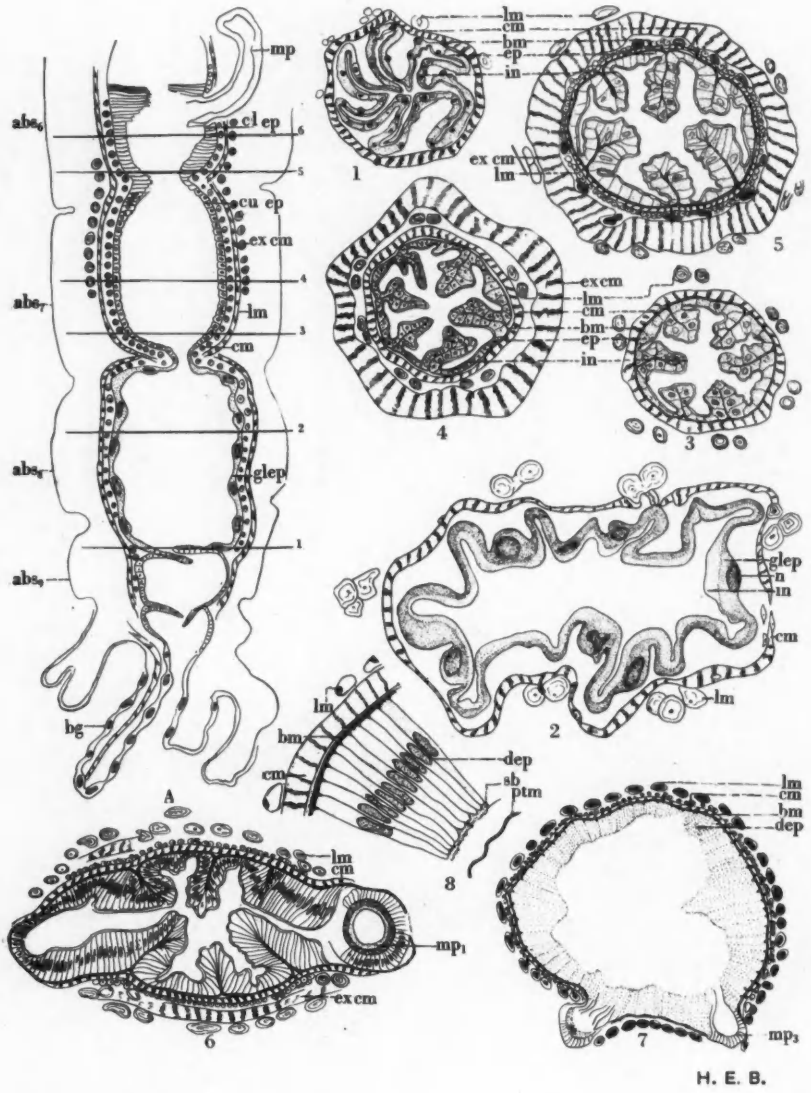

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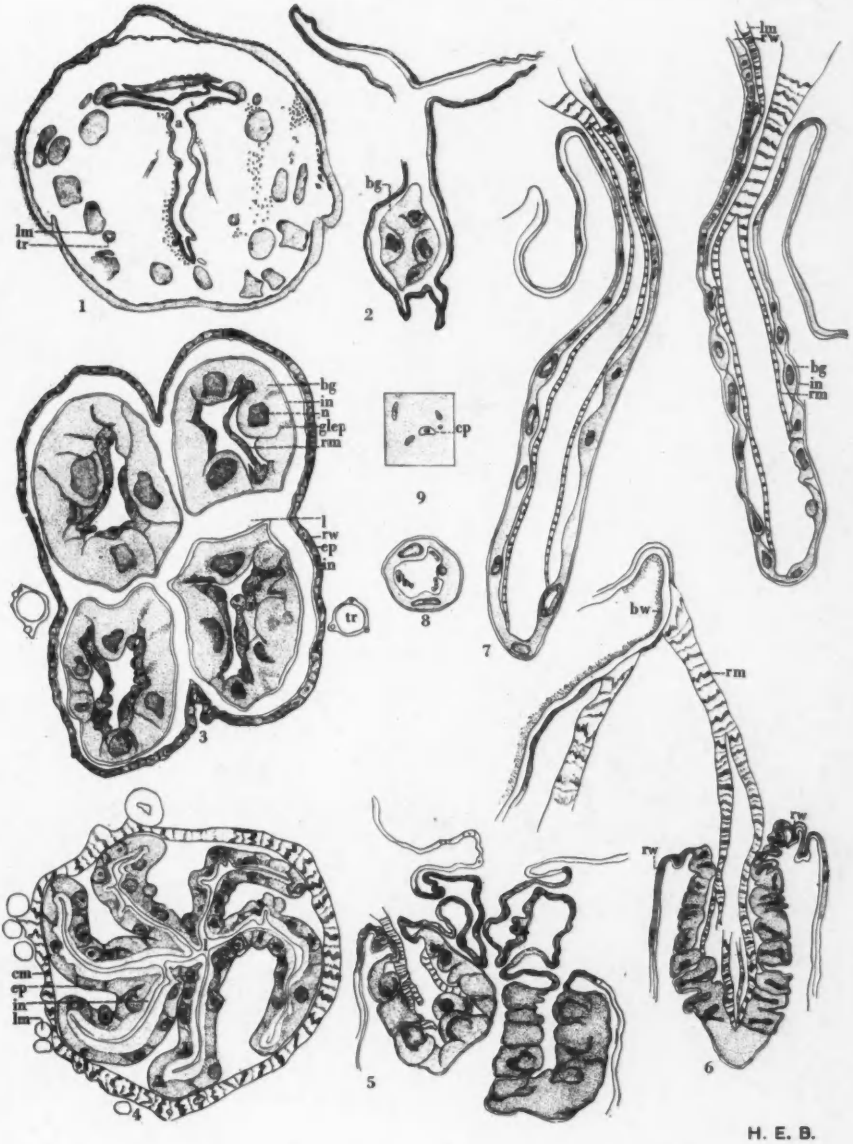

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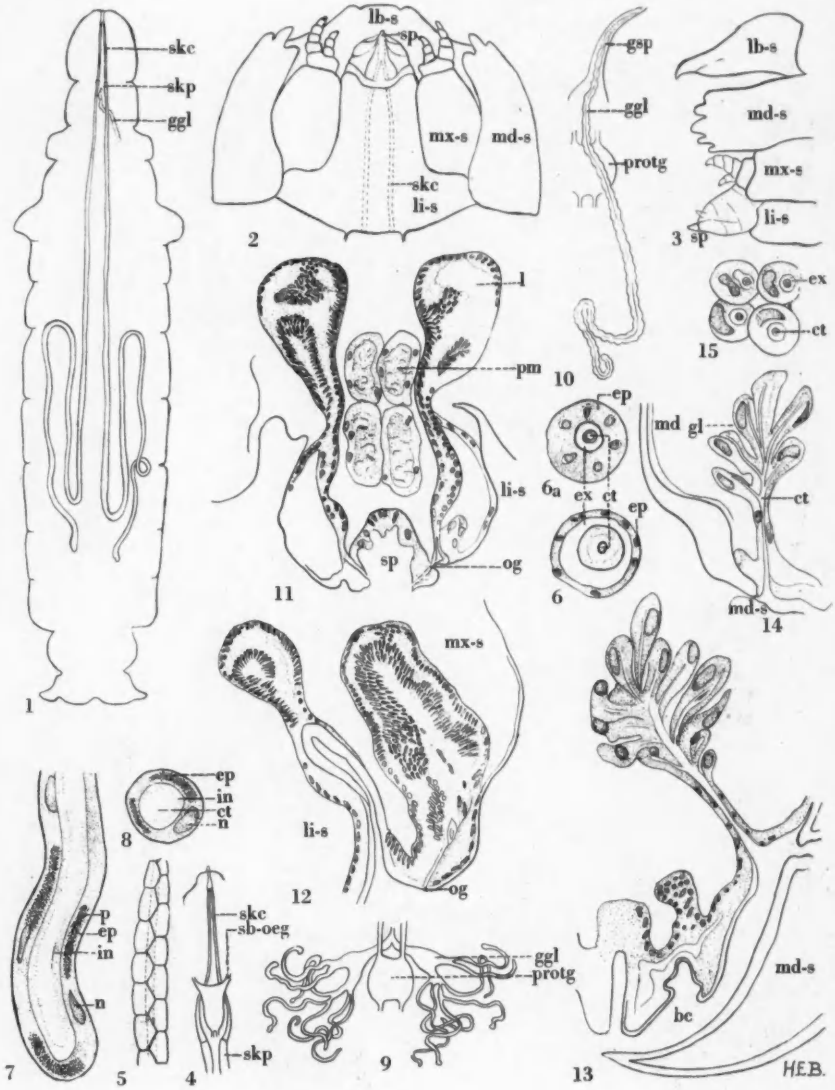

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